ANNALS

OF

The Entomological Society of America

Volume II JUNE, 1909 Number 2

INVESTIGATIONS OF TOXOPTERA GRAMINUM AND ITS PARASITES.

By F. M. Webster,

BUREAU OF ENTOMOLOGY, WASHINGTON, D. C.

This minute insect (see figs. 1, 2), aside from its economic importance, which, by the way, is very great, has become the basis of a long series of thorough investigations, carried out by several assistants of the Bureau of Entomology, under my direction. My own studies of the species were made largely during the years 1884 to 1890, while employed by the old Division of Entomology. As the subject of this paper may not be familiar to all entomologists it will be better to begin, historically at least, with our first knowledge of the species in its native country, if, indeed, we might with our present information, be allowed to designate for it a place of nativity.

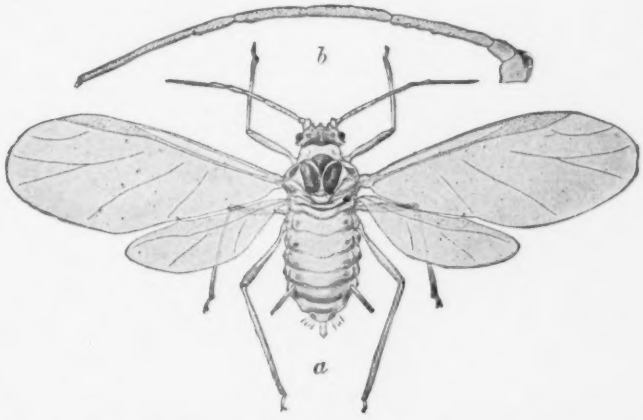


Fig. 1.—The spring grain-aphis (*Toxoptera graminum*): *a*, Winged migrant viviparous female; *b*, antenna of same. *a*, Much enlarged; b, highly magnified. (From Pergande.)

OCCURRENCE IN THE EASTERN HEMISPHERE.

It seems to have been observed at Parma, Italy, as early as 1847 (1). Five years later, in 1852, (1) Rondani, who described the species during this year, wrote to Professor Bertoloni under date of June 14, also from Parma, relative to the insect as follows:

"We have in our city an innumerable number of insects of a species of the Aphis genus, of Linnæus, of the order of Hemiptera.

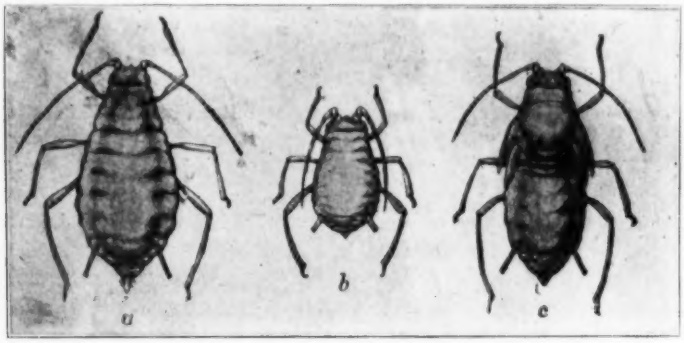


FIG. 2—The spring grain-aphis or "green-bug" (*Toxoptera graminum*: *a*, wingless female; *b*, larva; c, pupa. Much enlarged (from Pergande.)

Sometimes and in certain places the number of these insects flying in clouds in the air has been so great as to render them troublesome to people, entering the nose, eyes, and even the mouth when one cannot think how to protect oneself from them."

Elsewhere in this letter Rondani states that he had never been able to find it on any but graminaceous plants, where it nestled on the leaves. In commenting on this letter of Rondani, (1) Prof. Bertoloni takes occasion to say that:

"Innumerable specimens of the *Aphis graminum* Rondani, are seen in the streets of the city of Bologna and these have several times entered my nose and eyes when passing rapidly along the canal of Reno."

Passerini (2) excepted we find no mention of the insect again until 1884, when Dr. G. Horvath (3) mentions an attack on oats in Central Hungary in June, 1883. Ten years later, in 1894, Professor Karl Sajo, (4) records another outbreak, also in Hungary, again among growing oats.

Schouteden (5) in 1906, records the species from Belgium, but gives no further data except that it affects the graminaceæ.

In August, 1907, at the meeting of the International Society of Zoologists in Boston, and, later, also in Washington, I had the good fortune to meet Dr. Horvath and from him learned that the species had been found in Siberia on graminaceæ.

For two or three years past, grain in the Orange River Colony, South Africa, has been seriously affected by a species of Aphis, we having received several complaints of these invasions from Mr. H. Neethling, at that time, Chief of the Horticultural and Biological Division of the Department of Agriculture at Bloemfontein. It was only within the last few months, however, that we were able to secure specimens of these aphids for identification and, surprisingly enough, they prove to be *Toxoptera graminum*. With these were a number of individuals of a species of *Lysiphlebus*, allied to the one that is so efficient in holding the pest in check in America. This gives us records of the occurrence of the species in Europe, Asia and Africa.

OCCURRENCE IN THE WESTERN HEMISPHERE.

The earliest information we have of the occurrence of *Toxoptera graminum* in America is in the year 1882, when it was received at the Department of Agriculture, but sad to say there is no record as to where the specimens came from. Late in June, 1884, it was found sparingly on wheat in the vicinity of Cabin John, a short distance north of Washington, and, about the same time, I found it infesting wheat plants in some breeding cages where some experiments were being carried on by myself at Oxford, Indiana, about one hundred miles southeast of Chicago, Illinois. Nothing more was heard of the species until 1890 when a very serious and destructive outbreak occurred in the West, extending from northern Texas to Missouri and central Indiana. Curiously enough there was little complaint from the territory east of the Appalachian mountain system, even where considerable wheat and oats were being at that time grown. Again, we have a period of eleven years without noticeable injuries from this pest; then, in 1901, there came the most destructive outbreak that had occurred up to that time, but in this instance depredations did not extend farther north than central Oklahoma, though planters in South Carolina afterwards reported "green lice" as having been very abundant on oats during the spring of that year.

In March, 1903, there was an incipient outbreak of the species in northern Texas. But this seems not to have extended northward beyond the Red River and was overcome by parasites in

April. (6) This time it certainly did appear in excessive abundance on fall-sown oats in North and South Carolina, and planters became alarmed over its presence. It did not, however, work serious injury there.

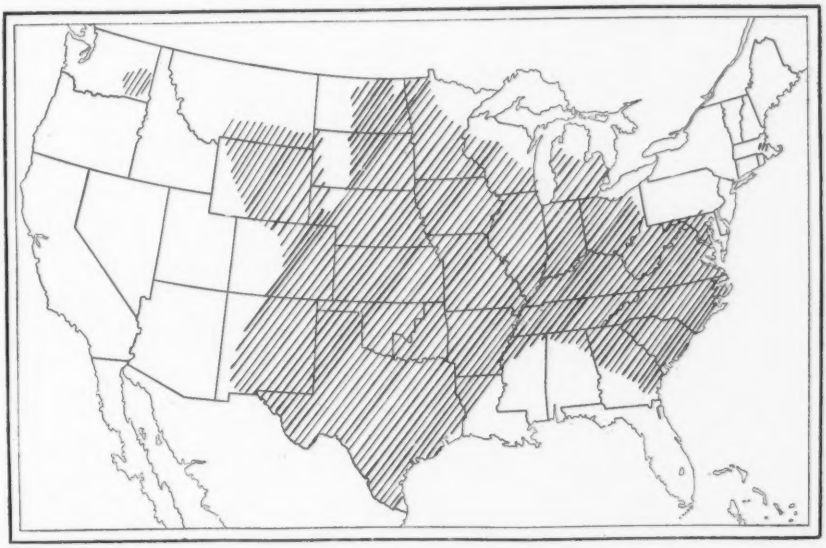
In December, 1906, the insect began to appear in fields of fall sown and volunteer oats in northeastern Texas. Throughout the winter of 1906–1907 they increased in abundance and by spring had ravaged the fields of both wheat and oats throughout Texas and Oklahoma, east of the 100° meridian, and as far north as Wichita, Kansas, but spring sown oats were damaged as far north as eastern Iowa, northern Illinois and southern Wisconsin. In the east there was also serious damage to wheat and oats in both of the Carolinas. The loss by reason of this outbreak would probably not fall short of $12,000,000 to $15,000,000 and proved to be much more serious than any preceding occurrence. Thus it will be observed that the species is becoming constantly more abundant, its re-occurrences more frequent and more threatening to grain crops, especially throughout the country between the Rio Grande and Missouri rivers. This is also true to a less degree in the Carolinas.

DISTRIBUTION IN AMERICA.

Most rigid searches have failed to reveal the presence of the insect in the country between the St. Lawrence river, Lake Ontario and Lake Erie, and the coast, to a line drawn from Cleveland, Ohio, to Philadelphia, Pa., although it would not be surprising if it extended farther northeast nearer the sea coast.* Neither has it been found in northern Michigan, northern Wisconsin, northeastern Minnesota, or in the arid region of western North and South Dakota or eastern Montana, where it has also been diligently searched for. It has not been found in Alabama, Mississippi, or Florida, but has not been searched for in those States. With these exceptions it ravages over the whole country east of the Rocky Mountains, from Mexico northward into Manitoba and Saskatchewan, and from an elevation little above sea level, to 8,000 feet in New Mexico. On the Pacific slope it is found in eastern Washington. Whether it also extends from Washington southward along the Pacific coast to Mexico is not known, because it has not been searched for in that portion of the country. (See map.)

* Mr. Paul Hayhurst, assistant to Dr. Wheeler, states that he has found it on oats, *Agropyron repens* and *Dactylis glomerata*, in the vicinity of Forest Hills, near Boston, Mass.

If we assume that Southern Europe is the original home of the species, its occurrence in the western hemisphere can only be accounted for on the score of introduction, but the distribution of the species in the eastern United States, does not in the least indicate such an introduction as having come through any of the Atlantic coast seaports. On the other hand, its occurrence all along the Rio Grande River bordering Mexico, together with its destructive abundance in northern Texas, as early as 1890, only



DISTRIBUTION OF TOXOPTERA GRAMINUM IN THE UNITED STATES.

eight years after its first discovery in America, goes far to strengthen the theory of an early introduction into some country to the South, and a natural diffusion over the United States, following the same lines of dispersion as for so many other species coming to us from Mexico and southward.

FOOD PLANT.

The species is essentially a leaf infesting insect, rarely infesting the stem. While preferring oats it will readily attack wheat, rye, barley, and may often be found on the underside of the lower leaves of corn. Corn excepted, its effect on the foliage of grain, when present in large numbers, is to cause the infested leaves to change to a red color, which seems to be very characteristic of *Toxoptera* and does not follow, to a marked degree, attacks of

other species of Aphids on these grains. The insect also has been found breeding upon a considerable number of native grasses any one of which may constitute its alternating food plant, upon which it may survive the summer in different portions of the United States. It has been found breeding freely upon *Alopecurus geniculatus* in Oklahoma by Mr. W. J. Phillips and by Mr. C. N. Ainslie in Kansas; on *Agropyron occidentalis*, also in Oklahoma, by Mr. Phillips; and by Mr. O. E. G. Kelly and Professor Gillette in Colorado. *Agropyron tenerum* was found moderately infested by Mr. C. N. Ainslie at Las Vegas, New Mexico. It was found breeding upon Bromus at Washington, D. C., and also upon *Bromus porteri* at Las Vegas, New Mexico, and on an undetermined species of Bromus at Mesilla Park, New Mexico, also by Mr. Ainslie. I observed it very abundantly on *Dactylis glomerata* in Indiana in 1890, and again excessively abundant in a small, isolated meadow, of this grass near Midlothian, Virginia, in April, 1907. This meadow was located in a region not adapted to the growing of grain and there was no field of growing wheat or oats within five miles. Mr. Kelly found it inhabitating *Distichlis spicata* in such abundance as to be damaging this grass in Montana, which in that part of the country is known commonly as "salt grass." It was found inhabiting *Elymus striatus* at Las Vegas, New Mexico by Mr. C. N. Ainslie. Mr. W. J. Phillips found it attacking *Hordeum pusillum* at Beloit, Kansas, and, Kingfisher, Oklahoma, while I found this to be of frequent occurrence throughout Kansas. Mr. Kelly observed it abundant on *Hordeum jubatum* in Montana, while Mr. C. N. Ainslie found it moderately abundant on *Hordeum cæspitosum* near Cimarron, New Mexico. Wherever *Poa pratensis* grows the insect will probably be found breeding upon it through the entire summer. In fact this has been actually observed to occur in the city of Washington. Mr. Phillips has also observed it in Indiana and throughout the northern sections of the country, where *Toxoptera* occurs; it is more likely to be found on this plant during summer than upon grain, excepting, perhaps, during seasons of excessive abundance. Mr. C. N. Ainslie also found it moderately abundant on *Polypogon monspeliensis* about Albuquerque, New Mexico. It has been found breeding on *Stipa viridula* at Las Vegas, New Mexico, by Mr. C. N. Ainslie, the grass being heavily infested. As one or more of these grasses will be found to occur in almost every portion of the United States, it would appear that the non-

occurrence of Toxoptera in any considerable section of the country cannot be due to a lack of uncultivated food plants. Mr. Phillips found that the species readily developed on the following plants in his breeding cages: *Dactylis glomerata, Eleusine indica, Eragrostis pilosa, E. megastachya, Sporobolus neglectus, Agropyron* sps., *Elymus virginicus, E. canadensis* and *Bromus secalinus.*

SEASONAL HISTORY.

Though in the main following quite closely the developmental habits of other Aphids, this species exhibits some striking contrasts. While it probably passes the winter in the egg state in the northern portions of the country, it is quite certain that it is not restricted to that mode of hibernation during mild winters, or in the South. The fact that viviparous ♀♀ (figs. 1, 2) sent from Leavenworth, Kansas to Washington, D. C., in March, and there placed indoors, produced oviparous ♀♀ (fig. 3) and ♂♂ (fig. 4) in April, and, in case of the latter, even till May 18, shows that the sexes may occur in spring. As information on the occurrence of the sexual forms appears to be entirely lacking in the South, it would be too much to connect the presence of these forms in spring as showing a changed summer condition in the South, whereby the dry season instead of the winter might be passed in the egg. Bearing upon this point, but proving nothing unfortunately, it may be stated that at Richmond, Indiana, in the autumn of 1907, Mr. Phillips encountered a pronounced lack of oviparous ♀♀, the weather being unusually wet. During a corresponding period of 1908, with one of the severest droughts on record prevailing at the time, he was unable to get a sufficient number of viviparous ♀♀ to keep up his experiments, while the sexual forms were present in abundance.

Two of my assistants, Mr. W. J. Phillips, and Mr. C. N. Ainslie, have on occasions dissected ♀♀ and found both eggs and embryos in the ovaries, the latter in spring; while the former, in the fall, observed in one instance that the eggs were in one side and the embryos in the other side of the abdomen, as though one ovary had produced eggs and the other embryos.

FIG. 3—Spring grain-aphis (*Toxoptera graminum*): Oviparous female with eggs in body, greatly enlarged; at right, egg still more enlarged. (Original.)

Mr. Phillips in a long series of breeding experiments carried out at Richmond, Indiana, has found that the oviparous ♀ will not deposit eggs without having first mated with the ♂, and usually produces not more than five or six eggs. The life of the viviparous ♀ is much longer than that of the oviparous ♀ but the life of the latter is greatly prolonged if she fails to meet the ♂ and become fertilized.

HIBERNATION.

The species will breed at about or a little above 45° Fah., though, as determined by Mr. Phillips, they do not reach their maximum until the temperature rises to above 50° Fah., which, however, is still too low to render their parasites active. As an experiment, a miscellaneous lot of individuals were frozen up in ice

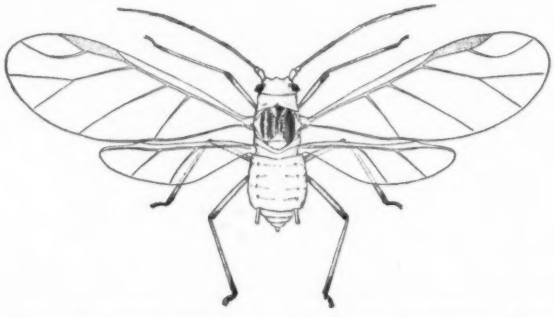


FIG. 4—Spring grain-aphis (*Toxoptera graminum*: Male. Greatly enlarged. (Original.)

for five, twelve and twenty-four hours respectively, and on being thawed out the older individuals all succumbed; in another twenty-four hours experiment, using individuals of different stages of development, only the pupæ of the viviparous ♀ survived. Viviparous ♀ ♀ brought indoors from a temperature of 11° Fah., and thawed out began to give birth to young in about three hours. Thus it is that the species is able to withstand the climate of northern latitudes and high altitudes. As it breeds freely in a temperature of 100° Fah., in the shade, presumably still higher in the open, on the public grounds in Washington, it would seem that farther south, where it was found by Mr. C. N. Ainslie, the insect would encounter even a greater degree of heat in summer. Thus we have a fairly good basis for the supposition that it

extends southward beyond the boundaries of the United States. So far we have not found the sexual forms south of southern Kansas, about latitude 37°, but north of this latitude it can certainly pass the winter ordinarily in the egg state and in mild winters as viviparous ♀ ♀ either wholly or in part developed. South of Lat. 37° there really seems to be no vital necessity for sexual ♀ ♀ in order to perpetuate the species or to enable it to pass the winter. Indeed, the greatest need would seem to be for some means of bridging over the dry period, during which there is a serious lack of food and in a temperature far too high to induce torpidity thus rendering food unnecessary.

DEVELOPMENT DURING SUMMER.

Beginning July 8, 1907, Mr. W. J. Phillips, at Richmond, Ind., began a study of the continuous generation of this species, following it through to December 10, besides securing sexual ♀ ♀ and eggs therefrom on blue-grass in the fields in October. With these eggs, he began March 27, 1908, to again follow out continuous generations, commencing with the first stem mother that hatched from eggs deposited the previous autumn. From the wintered over egg to the oviparous ♀, or from one egg stage to the other, the maximum was twenty-one generations of viviparous ♀ ♀ when the first born were used in each case, but only ten generations where the latest born was used in a parallel experiment. The experiment ended December 1, 1908. It is not unlikely that there are a greater number of generations produced in the south, where the warm period is more prolonged, though in the north this period while shorter is not usually so excessively dry.

Ordinarily, the viviparous ♀ will reach full development and herself begin reproduction about eight days from birth, but in late autumn this period becomes very irregular. In one case Mr. Phillips had a viviparous ♀ under observation, under outside conditions from the day of her birth October 18 to December 10. Though apparently fully developed she produced no young and went into winter in a most vigorous condition. It will be noted that it was just such as these that survived the freezing experiment previously described. The young, when born, are enveloped in a membraneous sack, from which they disengage themselves almost the instant they leave the mother. A viviparous ♀ may produce as many as 70 young scattering them throughout a period

of four to six weeks. The wingless viviparous ♀ ♀ are more prolific than the winged, but, of course, scatter their young less as they are confined to a very limited area. It is usual to observe a wingless mother stationed on a leaf in the midst of a family of a dozen or more young, varying in size from newly born to half grown. The insect moults four times.

EFFECT OF METEOROLOGICAL CONDITIONS.

As has already been shown, the direct effect of low temperature on the insect is, in the south at least, exceedingly small. It is vastly more probable that the influence of winds and humidity are much more important factors, though of the latter we cannot yet speak with the fullest assurance.

As has also been shown, it may turn out that hot dry weather may be found to greatly influence the time of appearance and abundance of the ♂ and sexual ♀.

Winds certainly do have considerable influence in the dispersion of the winged viviparous ♀ ♀, during the seasons of excessive abundance, and as it is well known that a diminution of the food supply, like the killing of the grain plants, tends to produce winged instead of wingless individuals, it will be seen at once that the occurrence of these winds at the time of a serious outbreak may become a powerful factor in the spread of the pest. Now, the prevailing winds in the Southwest during spring are from a southerly direction and as there is a continually increasing food supply to the northward as the season advances, these winds help the insects to keep pace with this advance. This diffusion might be likened to a horizontal revolving movement, the winged ♀ ♀ from a destroyed field passing over others along the border and settling down to breed, infest and destroy other fields more in advance, and so on day after day, thus passing over miles upon miles of young growing grain changing it from a luxuriant green to reddish brown, as effectually destroying it as would be the case were it to be scorched by fire. There are of course other modes of dispersion, and I have observed not only winged individuals but also parasites, clinging to the glass of the windows in railway coaches and in this way carried long distances.

Thus it is that an invasion of *Toxoptera*, originating in central northern Texas in a winter temperature above the normal, yet too cool to admit of its chief natural enemy becoming active, will

develop countless millions of winged viviparous ♀ ♀, and these will gradually become diffused northward as the season advances and weather conditions favor them. Indeed the experience of Rondani and Bertoloni, in Italy, found an equal in the southwest in 1907 where Mr. C. N. Ainslie observed the winged ♀ ♀ in such swarms as to interfere not only with a Sunday game of baseball, but also with the conducting of a funeral. North of about Lat. 38° the season is so far advanced that wheat becomes too large and tough to offer the requisite food supply, but spring oats here prove a convenient and attractive supplement and it is usually this crop that suffers most to the northward, provided, of course, the weather conditions are not favorable to the development of natural enemies.

NATURAL ENEMIES.

There are a number of these, especially among the Coccinellidæ, several species of which feed, both in the larval and adult stages, on *Toxoptera*. Syrphus flies and Chrysopa also destroy them. *Aphelinus nigritus* Howard, recently described, is a minute parasite that has been reared from this insect in South Carolina by Geo. G. Ainslie, and in New Mexico by Chas. N. Ainslie, both assistants in the Bureau of Entomology. Quails are very fond of them and Miss Margaret Morse of Clarke University has been kind enough to make some experiments for us in feeding these birds. Miss Morse estimates that about 5,000 individual *Toxoptera* were eaten by a single quail in one day, preference being shown for those that were unparasitized. The Song Sparrow, *Melospiza melodia*, also devours great numbers of them in the grain fields.

DEVELOPMENT AND INFLUENCE OF LYSIPHLEBUS TRITICI.

As a matter of fact, however, all of the natural enemies previously mentioned are of small moment as compared to the influence of the one minute parasitic species *Lysiphlebus tritici* (figs. 5, 6.). It is this species, or what we are at present terming as such, that normally holds *Toxoptera* in check in this country, and so long as its development and activity are not obstructed by meteorological conditions, it will probably continue to do so. Indeed so important is this insect and so powerful is its influence that only a short space of from ten days to two weeks time is

required for it to overcome a most serious outbreak of *Toxoptera* and thus save from destruction vast areas of growing grain. The species winters over in the fields in the bodies of its host. In many cases this hibernation is passed as nearly or quite fully developed adults, ready to emerge when the temperature rises to the neighborhood of 56° and continues for a sufficient length of time, and where they have been prevented from emerging the previous fall, on account of the advent of cold weather. This is clearly shown by the fact that Mr. E. O. G. Kelly found them in this condition at Leavenworth, Kansas, on November 13. From a lot of 50 parasitized *Toxoptera* that had been washed or rubbed off

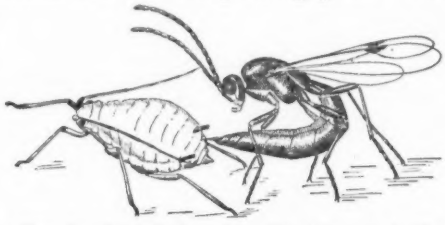


FIG. 5.—Lysiphlebus depositing its eggs in the body of a grain-aphis. Much enlarged (original.)

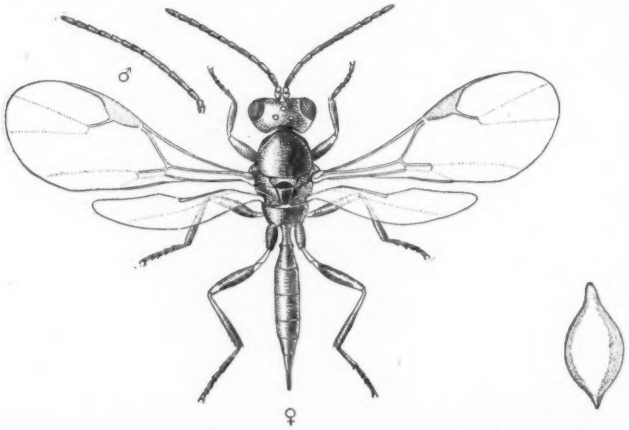


FIG. 6.—*Lysiphlebus tritici*, principal parasite of the spring grain-aphis; Adult female and antenna of male. Greatly enlarged (original). At right: Egg of *Lysiphlebus tritici*. Highly magnified (original).

the leaves of the young grain (fig. 7) and were taken out of the mud about the wheat plants on February 28, after the winter was practically over, Mr. Kelly found that of these 50 dead bodies, 17 contained full grown larvæ of the parasite, 12 contained pupae of a light color and 21 contained pupæ of a dark color, the latter

evidently ready to promptly develop with the advent of warm weather. Mr. Kelly, on the same date, also secured a large number of *Toxoptera* in various states of development that were hibernating in wheat fields near Leavenworth, Kansas. The weather had been such as to preclude the possibility of these having been recently parasitized. Yet some of them soon began to show the characteristic yellow color of a *Toxoptera* parasitized by *Lysiphlebus*, and adults were afterwards reared from them. This shows conclusively that *Lysiphlebus* hibernates in advance stages of development in the bodies of its host, which they have killed the previous autumn, as well as larvæ in hosts wintering over from half to fully grown.

FIG. 7.—Stalk of wheat, the leaves covered with dead spring grain-aphids killed by the parasite *Lysiphlebus tritici*. About natural size (original).

The ♀ *Lysiphlebus* is even more prolific than *Toxoptera*. Mr. Phillips has found ♀ ♀ with upwards of 400 eggs in their ovaries, and Mr. Kelly has reared in some cases 206 individuals from a single mother *Lysiphlebus*. The eggs are lemon shaped and white in color. When excessively abundant the parasite will thrust its ovipositor into old and young aphids of both sexes, including the sexual ♀, even though previously parasitized; and Mr. Phillips has observed them to apparently oviposit in the dead bodies of those that had been killed by fungus attack. When their numbers are not so great, they show more discrimination and seem to prefer half grown individuals in whose bodies to place their eggs.

This species of *Lysiphlebus* is parthenogenetic, as was first observed by Mr. Phillips at Richmond, Indiana, and afterwards more fully elucidated by Messrs. Kelly and Urbahns at Wellington, Kansas. The experimental breedings of Mr. Phillips in 1907 indicated that the offspring of virgin ♀ *Lysiphlebus* were always exclusively ♂ ♂. In a series of upwards of eighty breeding experiments carried on indoors, in 1908, by Kelly and Urbahns, only forty-eight gave results of any kind. Of these only four gave ♀ ♀, the other giving only ♂ ♂. In the four exceptional cases the ♀ ♀ kept virgin, ran all to ♂ ♂, two with the first generation, one with the second and one with the third. The mode of procedure was as follows:

Starting with a mated ♀, the ♀ ♀ from among her offspring were isolated, even before emergence; on their appearance these were given *Toxoptera* reared under cover to preclude parasitism; the few ♀ ♀ from among this second generation were again isolated in the same manner, the ♀ ♀ in all cases being kept unmated. It was thus found possible to breed a limited number of ♀ ♀ parthenogenetically to and including the third generation. Beyond this all offspring were ♂ ♂, this seemingly being the limit. Just why such a large percentage of these experiments should have proven abortive is not clear. The conditions under which they were carried out were of course unnatural but much more protected from the adverse elements of the open field.

The egg of the *Lysiphlebus* normally develops to the emerging adult in about ten days, during the first six of which the host insect remains alive, and at the end of that period commences to take on a yellowish hue, the larvae of the parasite showing clearly through the skin of the abdomen (fig. 8).

Some studies were made of the final larval stage by Miss Weeks, of Manhattan, Kansas, under my supervision, the results of which were given in brief by me at the first meeting of this Society in Boston, and are as follows:*

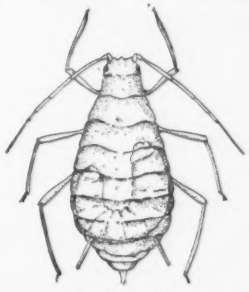
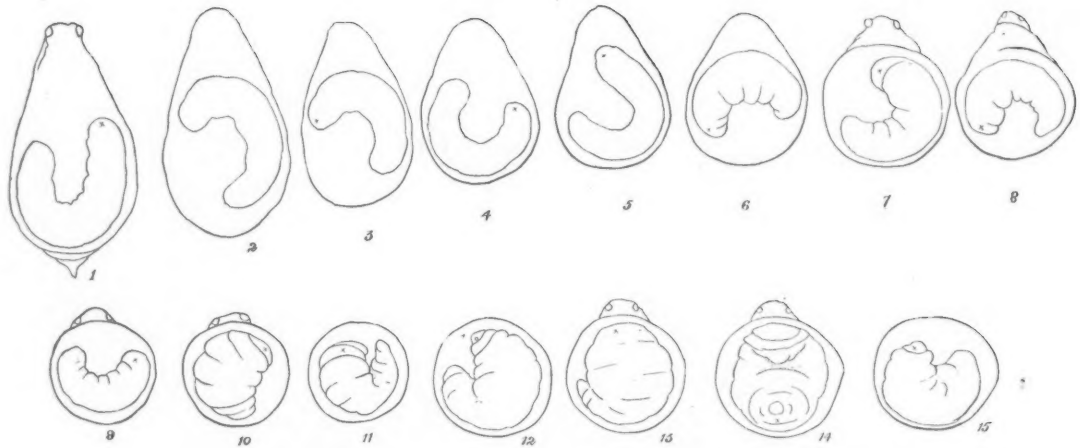


FIG. 8—Wingless female of spring grain-aphis, containing larva of the parasite *Lysiphlebus tritici*. Much enlarged (original).

A wingless ♀ of *T. graminum* was taken from the field when beginning to take on the yellowish color, which first denotes parasitism, and which precedes the amber color of the more advanced stage. Evidently this was on or about the sixth day from the time of oviposition by the *Lysiphlebus*, the larva being at the time quite full grown and occupying its normal position in the posterior part of the abdomen of the host insect. From all that we have been able to learn the very young parasite larva takes this position, and, refraining from moving about to any considerable degree, it does not come in contact with or injure any vital organ of its host, the effect being to reduce the period of reproduction of the ♀ *Toxoptera* to a very few days at most. But on reaching its full larval development, it seems suddenly to become more active, and with its first extended travels within the abdomen of its victim the last spark of life remaining in the latter is extinguished. It was just at this point that the observations herein recorded were made.

On bringing the ♀ *Toxoptera* from the field and placing it under the microscope, the *Lysiphlebus* larva was observed to work its way actively about as shown by the accompanying plate, these movements being always forward and easily observed through the skin of the victim until this had become too opaque. The movements of the parasite larva were accompanied, on the part of the victim, by a clutching of the leaf and a rigidity of the muscles of the limbs. But it has since been learned that this *rigor mortis* has little if anything to do with the adherence of the cocoon to the leaf surface, as was previously supposed by me, except perhaps to temporarily hold the body of the aphid fast until the parasite larva can anchor it more securely. (See Proc. Ent. Soc.

* These observations were afterwards published in Proc. Ent. Soc. Wash., Vol. IX, Nos. 1–4, pp. 110–113, Plate VI.



THE FASHIONING OF THE PUPAL ENVELOPE IN LYSIPHLEBUS TRITICI ASHM.

F. M. Webster.

Wash., Vol. IX, p. 111.) Later observations by Mr. Kelly on the movement of the parasitic larva, made from beneath and after the dorsal skin of the host had become too opaque to continue them from above, shows that the ventral skin of the *Toxoptera* splits and the slit thus formed widens, as the skin assumes a rotund shape, until it becomes nearly circular. The parasite larva spins a cocoon of silken threads within the empty skin of its host, and, by reason of this disc-like hole in the ventral surface of the host skin, attaches the whole structure firmly to the surface of the leaf.

Taking up these observations in detail, figure 1 of plate XIV shows the host as when first placed under the microscope at 11 A. M., while she was still alive and at a time when she seemed to tighten her grasp on the leaf with each movement of the parasite larva within her body. Between 11 A. M. and 11:35 A. M. the *Lysiphlebus* larva had made three complete revolutions in the body of its host, some of the different positions assumed, as also the gradual shaping of the skin of the now dead *Toxoptera* being illustrated by figs. 2–7 in the plate. Between 11:35 and 11:40 A. M., the larva had completed another revolution, probably the fourth from the beginning. The fifth revolution was completed by 11:30 A. M., and the sixth at 11:58 A. M., while the seventh was completed by 12:07 P. M. With the eighth revolution, shown by figs. 8 and 9, completed at 12:11 P. M., the skin of the host insect had been brought into its rotund shape and the larva had just begun to contract preparatory to pupation. At 12:15 the ninth

EXPLANATION OF PLATE XIV.

FIG. 1—Position of larva of *Lysiphlebus tritici* in body of wingless adult ♀ of *Toxoptera graminum*, just before beginning its revolutions for fashioning the body of the Toxoptera into a pupal envelope, 11 A. M.

FIGS. 2–7.—Some of the positions assumed by the Lysiphlebus larva between 11 A. M. and 11:35 A. M., during which time it made three complete revolutions.

FIGS. 8, 9.—Positions during and at completion of eighth revolution, 12:11 P. M.

FIG. 10.—Position at completion of ninth revolution, showing contraction of the larva, 12.15 P. M.

FIG. 11.—Position at 12:20 P. M.

FIG. 12.—Position at 12:22 P. M.

FIG. 13.—Position at 12:27 P. M.

FIG. 14.—Position at 12:32 P. M.

FIG. 15.—Position at 12:32½ P. M.

rotation (fig. 10) had been completed and the larva had decidedly contracted. Fig. 11 shows the situation of both larva and pupal envelope at 12:20; fig. 12, at 12:22: fig. 13, at 12:27: fig. 14, at 12:32, and fig. 15, at 12:32½ P. M. At 12:35 P. M. there were apparent on the body of the parasite larva small, roundish cells of a yellow color. By this time the skin of the host had reached the semiglobular, typical form, which did not materially change afterward, though a slight movement in the larva could be detected up to 4 P. M., after which the covering had become too opaque to permit of further observations. Thus, within the space of five hours the living body of the host had been transformed into a tough, dried, hardened protective covering the cocoon of the parasite during its short pupal stage, by a process of manipulation by the larva and a natural tanning process which renders the skin of the dead Toxoptera so impervious to the weather that these skins so prepared, may be washed off the leaves by beating storms, yet do not become easily disintegrated, and may often be found in quantities on the ground underneath the infested grain plants.*

FIG. 9 – Unusual position of larva of *Lysiphlebus tritici* in body of *Toxoptera graminum*. Enlarged (original).

While the normal position of the larva of the parasite in the abdomen of the host is indicated in Plate 1, fig. 1, there are exceptions, as shown by a case where, in a very young *Toxoptera*, the position illustrated in text fig. 9 was assumed. This, however, is unusual. Again, while the transformation of Lysiphlebus from egg to adult takes place within the pupal envelope, as previously described, and the adult makes its way out by way of a small disc which it gnaws through both cocoon and skin and pushes outward, as shown in fig. 10. Yet, sometimes, the larva works out of this case prematurely, as shown in text fig. 11. This may, perhaps, be due to some mishaps in constructing the anchorage previously mentioned. Mr. C. N. Ainslie found several of these prematurely issued larvæ on the ground in wheat fields in Kansas, under very seriously infested grain plants where the *Toxoptera* were very much parasitized.

* NOTE: Mr. Kelly has since found that the parasite slits the ventral skin of the host, and, widening the rent spins a cocoon within the aphis skin and anchors it fast where the slits are situated.

The celerity with which an invasion of *Toxoptera* is overcome by *Lysiphlebus*, is frequently a matter of wonder, as it hardly seems possible that this host alone could be the source of the swarms of individuals that make their appearance after a few warm days have elapsed, in the midst of an unseasonably cool spring, preceded by a winter abnormally mild.

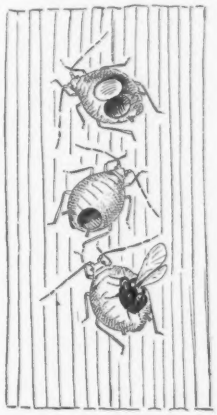


FIG. 10—Dead "green bugs," showing hole from which the matured parasite of *Lysiphlebus tritici* emerges. The top figure shows the lid still attached, but pushed back; the bottom figure shown the parasite emerging. Enlarged (original.)

In order to determine the origin of these myriads of parasites, Messrs. Kelly and Urbahns began a long series of experiments at Wellington, Kansas, to determine whether there might not be a multiplicity of host species from which great numbers of *Lysiphlebus* would emanate to fall upon and destroy *Toxoptera* whenever it becomes excessively abundant. The entire failure to introduce these parasites in advance of an invasion of this character from the south, as was the case in Kansas in May, 1907, has indicated that such introductions were not possible and that to attempt it was a veritable carrying of coal to Newcastle.

Female *Lysiphlebus* from *Aphis brassicæ* taken from the field were first bred into *Toxoptera* from which adults were obtained.

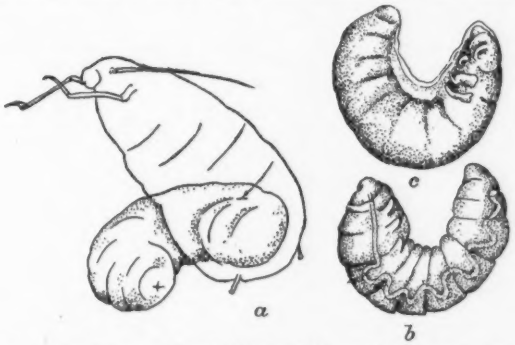


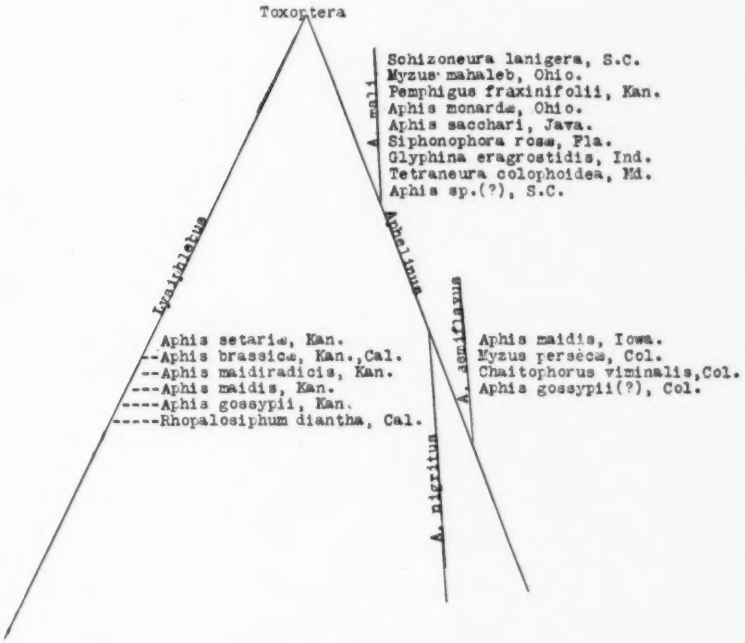
FIG. 11—*a*, Larva of *Lysiphlebus tritici* working its way prematurely from body of *Toxoptera graminum*; *b*, same larva, somewhat further developed; *c*, same, still more developed. Enlarged (original).

This experiment was several times repeated. Female *Lysiphlebus* reared under cover from *Aphis maidiradicis* were in two cases bred into *Toxoptera* and adults obtained. Female *Lysiphlebus* were reared from *Aphis setariæ* from the field and the issuing parasites in two cases were bred into *Toxoptera* and adults secured. This was also repeated several times. Female *Lysiphlebus* reared from *Aphis maidis* from the field, the adult parasites were bred into *Toxoptera* and adults emerged. Repeated several times. Female *Lysiphlebus* from *Aphis gossypii* from New Mexico and the adults successfully bred into *Toxoptera*. Female *Lysiphlebus* reared from *Aphis setariæ* from the field were bred into *Toxoptera* thence into *A. maidiradicis* and back into *Toxoptera*. Female *Lysiphlebus* from *A. setariæ* taken from the field and bred into *Toxoptera*, then back into *A. setariæ* again into *Toxoptera* and then into *A. brassicæ* from which adults were secured.

In many cases these breedings were reversed. The only cases of failures were in attempting to breed *Lysiphlebus* from *Toxoptera* into *Chaitophorus*; and in attempting to breed *Lysiphlebus* from *Toxoptera* into *Macrosiphum rudbeckiæ*. These experiments were reversed with the same results.

These experiments will be carried further another year, as it seems that host habits if we may term them such may possibly divide the specific position of the parasite in future.

The following diagram will serve to illustrate the additional host insects of the species of *Lysiphlebus* and *Aphelinus* that are known to also attack *Toxoptera*. This shows the varied host sources from which parasites may come in case of a serious invasion of *Toxoptera*.



BIBLIOGRAPHY.

(1) **Rondini, Camillo,** Nuovi Annali delle Scienze Natural, Serie III, Tom, VI, pp. 10–12, 1852. See also Afidicidi, 1847.
(2) **Passerini, Giovanni**, gli Afidi. Pamphlet, p. 25, 1860.
(3) **Horvath, G. Rovartani Lapok**, Vol. I, p. 143, 1884.
(4) **Sajo, Karll, Zeitschr.** f. Pflaugenkrankhaiten, Vol. IV, p. 4, 1894.
(5) **Schouteden, H.** Mem. Soc. Ent. Belgique, XII, p. 231, 1906.
(6) **Sanderson, E. D.,** Bull. 46, Bu. Ent., U. S. Dept. Agr., p. 93, 1904.

OBSERVATIONS ON A GALL APHID (APHIS ATRIPLICIS L.).*

PAUL HAYHURST.

The subject of this article is the common greenish insect of the genus *Aphis* which colonizes the dorsal surface of the leaves of the white goosefoot or lamb's quarters, *Chenopodium album*, and the nearly allied orache, *Atriplex patula*, in summer. The margins of the infested portion of the leaf always curl up longitudinally and meet above the midrib, forming an imperfectly closed tube.

According to the determinations of Mr. T. A. Williams and of Doctor Forbes, *Aphis atriplicis* also attacks the leaves of cultivated beets in Nebraska and Illinois. This would not be at all surprising, since the genus *Beta* is closely related to *Chenopodium* and *Atriplex*. Doctor Bruner wrote me that Mr. Williams was well acquainted with the insect and knew its characteristic habits on goosefoot. This aphid is very abundant on the common goosefoot and orache, from which it might easily become troublesome on beets.

At Fredonia, N. Y., it was everywhere abundant on the white goosefoot during August, 1908, when I first became familiar with its habits, although I did not determine it specifically until the following January. Most plants of this host were badly infested both in the vicinity of Fredonia and also at Lily Dale, Jamestown, and Chautauqua, N. Y. It has been reported as infesting this plant from Missouri, Kansas, Minnesota, Colorado, Illinois and Nebraska. Professor G. Del Guercio, Florence, Italy, writes me that this species is everywhere common in Europe on plants of the goosefoot family. I find in the literature that it has been reported from the following countries: Sweden, Germany, Italy, England and Belgium.

In habits this species is unique. The insects were infesting only the dorsal surface of the leaves and no other part of the plant when I was studying them last August. They were clustered chiefly along the midribs and main veins. The elongated galls (Fig. 1), which were formed by the sucking on the upper surface, partially protected the occupants from rain and sun. The margins of the leaves were never rolled in or convoluted more than I have shown in Fig. 1, a–b, which are cross sections of represen-

*Contributions from the Entomological Department of Bussey Institution, Harvard University, No. 5.

tative galls. Thus whenever the galls retained the normal position of the leaves with the dorsal surface upwards, they were easily filled with rain-water; in most cases, however, they were partly or entirely reversed bringing the ventral surface upwards and directing the long aperture of the gall downwards. Such galls were effectual water-sheds and the inhabitants were always dry, while those that were not reversed carried more or less water mixed with the excretions and exuvia of the plant lice. This liquid was evidently detrimental to the insects, many of which were killed by a parasitic fungus. An ample supply of these brownish dead aphids was sent to Professor Roland Thaxter of Harvard University, who replied as follows: "* * * * the fungus which has attacked them is *Entomophthora aphidis*, a universally distributed form with which two others are often associated. In your material, however, I see but the single species mentioned." It is clear, then, that the reversal of the gall is a decided advantage to the species. I was not able to determine how this reversal was brought about. It was evidently one of the curious effects on the leaf caused by the sucking of the insects, and may have been developed by natural selection for their protection from dampness and disease. The upturned whitish under surface of the leaf-galls rendered the infested plants very conspicuous, and gave them the deceptive appearance of being attacked by a downy mildew. I have, in fact, noticed this phenomenon in the *Chenopodiums* in Chautauqua County, N. Y., for several years and had always supposed it to be the work of a fungus until I examined them critically last summer.

A black aphid, the *Aphis rumicis* L. of authors, commonly infests the lower surface of the leaves and the inflorescence of these plants. It also sometimes occurs mixed in the colonies of the green aphids under discussion. This habit undoubtedly accounts for Buckton's mixed descriptions. The green and the black forms are entirely distinct species easily separable by pronounced structural differences, as pointed out in the descriptions farther on.

During the first week in August, 1908, the winged viviparæ (viviparous females) of *Aphis atriplicis* were leaving the galls in great numbers, a general migration being apparently at its height. After the middle of August pupæ were not common in the galls, which were almost deserted, except for a few wingless viviparæ and larvæ. Connold, 1902, observed a similar migration in August in England. I failed to find what became of the winged

females. Many individuals were found isolated on bean leaves, but none of these succeeded in establishing colonies. The migrants were certainly not depositing larvæ on the normal leaves of the *Chenopodiums*. About the middle of October, 1908, at Forest Hills, Mass. I found many small plants of this genus growing in soil that had been cultivated or newly made after July. These plants must have come up late in summer. They were covered with the galls of this species. It is evident, then, that they were colonized in August. Undoubtedly the winged females observed migrating at Fredonia in the same latitude were merely colonizers on tender young *Chenopodiums* starting up in damp situations. It is highly improbable that these were true migrants going to some distinct host. As a rule the sexes of truly migrating plant lice develop on some woody plant called the primary host, while the summer forms of the species live on a succulent herb, the secondary host. Since the sexes of *Aphis atriplicis* developed in great numbers on the *Chenopodiums* last fall, they are undoubtedly confined in their life-cycle to these plants and their allies.

On September 21st the perfect sexes were first noticed on the white goosefoot at Forest Hills. Small, lank, wingless males of a yellowish color, with blackish appendages, were actively climbing about over the large clusters of plump oviparous females, and copulation was observed as late as the 30th of October. Large numbers of these females were found abundantly on the goosefoot plants in this neighborhood. The males were few in number, between 5 and 10 per cent. of the total number of individuals (by guess). But they were making up for their fewness by great activity, and copulation was often seen. Most of the females had left the summer galls and were on the seed-heads, where they were frequently mixed with black aphids, the so-called *Aphis rumicis*. Only a small proportion of the individuals were found in the galls during the periods of oviposition. No viviparæ were seen at Forest Hills, and of many specimens taken throughout the fall, none proved to be viviparous on examination in the laboratory. Viviparity doubtless ceases or becomes exceptional in this species with the development of the perfect sexes. There is evidently a general migration of these sexes or of the sexuparæ producing them from the galls to the seed-heads in the fall, where the eggs are usually laid. Oviposition was observed during the entire month of October. The eggs were at first light yellow in color, then deep green, finally becoming shin-

ing black a few days after they were laid. They were generally placed irregularly on the calyces and seed capsules and on the small leaves of the upper branches. I examined many of the large galls finding some eggs in them, but not nearly so many as on the seed-heads. On October 21st I did find many eggs in some frosted wilted leaves. The general instinct of the females was plainly to carry the egg-laying as far up towards the seed-bearing portion as possible. On Nov. 11th no more living aphids of this species were found, for a freeze had killed all the *Chenopodiums*.

This habit of ovipositing on or close to the seeds is an instructive adaptation to the nature of the host. The winds and storms of the winter of 1909 have broken off all the seed-heads and leaves of the *Chenopodiums*, and at the time of writing (April) even the bare stalks of the plants rarely remain standing. The seeds have been distributed far and wide and many of the eggs of the aphids must have been carried with them. The young stem-mothers on hatching will be able to find their natural food easily available. Were most of the eggs laid on the leaves, they would be so scattered by the winds that very few of the larvæ could find suitable food in the spring. Since most species of *Chenopodium* and *Atriplex* are annual, the stem-mothers would suffer the same mishap if the eggs from which they hatched had been laid on the ground beneath the host. In October and November, 1905, at Columbia, Missouri I observed the large red *Macrosiphum rudbeckiæ* Fitch ovipositing in great numbers on the debris under one of its hosts, a perennial goldenrod. In this case new shoots would have come up in the spring around the old plants, and the larvæ on hatching would have found ready food. Here then, there was no necessity of the mothers entrusting their progeny to the capriciousness of the windy winter elements.

The oviposition of our goosefoot aphid in the seed-heads explains its world-wide distribution. Professor M. L. Fernald, Harvard University, has written to me that *Chenopodium album* is known to be an introduced plant from Europe, whence it has followed the trail of the early American settlers. In Professor Fernald's own explorations in the forests of Maine, New Brunswick and Quebec this plant was never found except about settlements. *Atriplex patula* is likewise recognized as an introduced species. These plants are both common European garden weeds whose seeds, with the eggs of their insect foes, could easily be introduced with any rubbish into a new country.

The wingless males are interesting types of degeneration (Fig. 3). They have not only lost their wings, but the thoracic lobes are also disappearing. In most specimens of about a score examined these structures are distinctly traceable, although reduced, and compare well with those of any winged form of the genus *Aphis;* but in some individuals they are degraded to mere vestiges in the shape of irregular dusky marks. In these more degenerate specimens only the ocelli, present in all winged aphids, prove that they were, until comparatively recently, winged insects. In this species we may hope to find occasional males still retaining their wings. Weed has shown that both winged and wingless males occur in *Cladobius salicis* L., and Gillette has found both forms in *Aphis torticauda* Gillette. No winged males of *Aphis atriplicis* were found this fall, although I kept this possibility constantly in view. On October 15th I did find three winged males in copulation with females of this species, but the males could not possibly be the same species, for they were generically distinct. This observation suggests the possibility of hybridization in the plant lice. Weed in 1891 observed the copulation of a male of *Cladobius salicti* Harris with a female of *Lachnus platanicola* Riley. These records also teach us that the mere pairing of two plant lice does not prove their specific or generic identity. The former can, however, be safely inferred when many males are found pairing with a large number of females possessing similar structural characters.

The wingless males of a red *Myzus* (?) on cherry (not *Myzus cerasi* Fab.) collected at Forest Hills last fall, have degenerated much farther than those of our *Chenopodium* aphid. Here all traces of thoracic lobes have disappeared, and the ocelli are scarcely discernible. A still farther step in degeneration has apparently taken place in the wingless male of the corn-root aphis (*Aphis maidi-radicis* Forbes), if we may judge from Forbes' figure and the descriptions by the same writer, Weed, and Davis, in which no mention is made of the ocelli. There would be no way of recognizing this male as a descendant of a winged male ancestor were it not for these intermediate forms, which I have discovered. This process of reduction of structures correlated with the organs of flight is an instructive illustration of what must have occurred long before in the evolution of the wingless vivipara, which has even lost all traces of ocelli. These facts also suggest the probability that this female in the *Aphididæ* is not a case of pædogenesis as

usually supposed, but is morphologically equivalent to a winged vivipara which has lost her organs of flight and all correlated structures through disuse. Living as parasitic insects in the midst of a luxuriant supply of food all superfluous structures have been dispensed with according to the well known laws of parasitism. When the males of a species are wingless, they must pair with females which have developed on the same plant and which may be of the same descent. The general migration of *Aphis atriplicis* in August observed by Connold and myself undoubtedly tends to counteract cross fertilization, since the bisexual colonies on any plant in the fall would be of mixed descent. According to the literature which I have seen, wingless males are known in the following species: *Pemphigus attenuatus* Osborn, *Schizoneura corni* Fab., *S. americana* Riley, *S. lanigera* Hausm., *Hamamelistes spinosus* Shim., *Hormaphis hamamelidis* Osten Sacken, *Chermes* and *Phylloxera*, all species as far as known, *Melanoxanthus salicis* L., *Lachnus nudus* De G., *L. piceicola* Cholodk., *Aphis maidiradicis* Forbes, *A. atriplicis* L., *A. mali* Fab., *A. carbocolor* Gillette, *A. torticauda* Gillette. Buckton reports wingless males in ten other species, but since I know the winged males in four of these and since his work seems so generally superficial, I do not give his list.

Aphis atriplicis was greatly parasitized both at Fredonia and at Forest Hills. On some plants nearly all the aphids were killed. I am indebted to Mr. C. T. Brues, Curator, Public Museum of the City of Milwaukee, Milwaukee, Wis., for the determination of the following parasites which I reared from this species: *Lysiphlebus eragrostaphidis* Ashm., Fredonia, N. Y., Aug. 3, 1908. Several specimens. From viviparous aphids. The other parasites were all reared from Forest Hills material and must have developed very largely in the oviparous insects. *Lysiphlebus eragrostaphidis* Ashm., Oct., 10, 23 and 30; many specimens. *Pachyneuron micans* Howard. Oct. 30, one specimen. *Asaphes rufipes* Brues, n. sp. Oct. 30, four specimens. *Aphycus* ? sp. an *Encyrtid*. Oct. 30, one specimen. *Figites*, sens. lat., aberrant *Cynipidæ*. Mr. William Beutenmuller suggests that these may belong to the genus, *Allobia*, known to be parasitic in plant lice, but no one in this country has time to study them for me. Oct. 30, nine specimens.

Several lady beetles were collected from galls of this aphid at Fredonia. Adult examples of these were kindly determined for

me by Mr. E. A. Schwarz through the courtesy of Doctor Howard as *Scymnus americanus* Muls. and *Hippodamia 13-punctata* L.

The aphids were not attended by ants. This may have been due to the dry time of the year, when, as Professor Wheeler tells me, these insects are not generally so active outside of their galleries. It is possible, however, that *Aphis atriplicis* does not attract ants at any time of the year. Mr. J. J. Davis has found that *Sipha flava* Forbes is never attended by ants in Illinois and I have noticed the same fact relating to this species in the early summer in Virginia and New York when ants were plentiful in the colonies of other aphids. It is also a matter of common observation that woolly aphids are rarely or never cared for by ants.

The identification of this species was not difficult on account of its peculiar habits. The original description by Linnæus is as follows: "Habitat in Atriplicis littoralis foliis, quae inde revoluntur longitudinaliter in cylindrum, intra quem vagantur obtectæ. Descr. Corpus viride: corniculis minutis. Oculi nigri." It will be seen that this description is less ambiguous than those of many species unhesitatingly referred to Linnæus, and I prefer to use it to avoid multiplying names. Specimens of the winged and wingless viviparæ were sent to Professor Del Guercio who is familiar with the species in Europe, and he found them to be identical. He placed this species in his genus *Uraphis* which is distinguished from other subdivisions of *Aphis* by the cornicles being shorter than the cauda. Since the cornicles are distinctly incrassate, he proposed a new subgenus of *Uraphis*, to be called *Hayhurstia* Del G. This subgenus would then include all species of *Aphis* with incrassate cornicles which are shorter than the cauda. Del Guercio separates *Siphocoryne* Pass. from *Aphis* by the cornicles which are "more or less long, clavate." (Nuov. Relazioni R. Stazione di Ent. Agrar. Firenze (1) No. 2, 1900, p. 142). By general consent those species of Aphis with more or less clavate cornicles which are longer than the cauda have been put in the poorly defined genus, *Siphocoryne*. In other words, *Hayhurstia* Del G. is separated from *Siphocoryne* Pass. merely by the length of the cornicles and a supposed difference between *clavate* and *incrassate*. These I consider too indefinite to be reliable generic characters. When forms are found with the cornicles *about* the length of the cauda, very careful measurements must be taken to determine the genus, and ocular micrometers are not always at

hand. Since every gradation exists in the degree of the bulge in the cornicles of the genus *Siphocoryne* from forms like *S. salicis* Monell down to *S. avenae* Fab. which is scarcely incrassate at all and that on the inner side, I cannot recognize either *Siphocoryne* or *Hayhurstia* as valid genera, but would rank them both as subgenera of the genus *Aphis*. I therefore consider the following grouping of those species of *Aphis* and *Siphocoryne* with a distinct cauda worth testing. This is modified from Del Guercio's revision of *Aphis* (Redia, Firenze Vol. 4, Fasc. 1, 1906, pp. 191–2.)

1. Cornicles longer than cauda.
   a. Cornicles cylindrical or gradually attenuated from base.
      Subgenus **Aphis** L. (Fig. 13.)
      Aphis sambuci L.
   b. Cornicles clavate or incrassate at or beyond base.
      Subgenus **Siphocoryne** Pass. (Fig. 11.)
      Aphis nymphææ L.
2. Cornicles equal to cauda or shorter.
   a. Cornicles cylindrical or gradually attenuated from base.
      1. Cornicles shorter than style.
         Subgenus **Uraphis** Del G.
         Aphis genistæ Koch.
      2. Cornicles equal to style.
         Subgenus **Microsiphon** Del G.
         Aphis tarmentillæ Pass.
   b. Cornicles incrassate.
      N. Subgenus **Hayhurstia** Del G. (Fig. 12.)
      Aphis atriplicis L.

Aphis atriplicis L. seems never to have been carefully described. In the following descriptions all colors were taken from the living insects with a high power hand lens, daylight, and many individuals were compared. All measurements of the bodies are from formalin material and are therefore reliable, while those of the appendages are from balsam mounts; the lengths given are averages of six or more representative specimens. Figures in parentheses are extremes. Del Guercio states that the colors especially of the wingless viviparæ in Italy vary greatly according to the host and other conditions so that "now greenish-yellow forms preponderate, and now those of a yellowish-green, green, olive green and olive color, sometimes, indeed, so deep in tint as to seem brownish with greenish reflections."

The lobes of the mesothorax are figured for clearness, because they are not generally mentioned individually by authors (Fig. 2). Their color is here treated as of specific value, but their form is not described for this purpose. Their structural details present marked constant differences, which have apparently never been carefully studied. They are already called the prescutum, scu-

tum, (scutal lobes), scutellum and postscutellum by some aphidologists, and I accordingly use the same terms, although I do not know their homologies. I avoid the long term *viviparous female* giving preference to its simple equivalent, *vivipara* (pl.–æ), which, being a classical word of the feminine gender, means literally *the viviparous female.* Since all viviparous plant lice are necessarily females, I can see no ambiguity in the use of this word.

Winged vivipara. Head dusky green; antennæ dusky with pale articulations, sparsely hairy, joint III, usual number of sensoria 9 or 10, sometimes 11–13 (Figs. 10, 15, 18); eyes dark red; beak extending beyond transverse sternal suture, but not reaching middle coxæ. *Pronotum* dusky green; lateral tubercles present, not prominent, longer than broad. Mesothorax greenish yellow; prescutum, scutal lobes and postscutellum blackish, scutellum (in formalin) brownish with black anterior and posterior margins; mesosternal plates brown, metasternal region dusky; 1st and 2nd discoidal veins of the forewing more or less distinctly joined to radius, never completely atrophied at base (Fig. 6). Base of femora brownish yellow, elsewhere dusky; tibiæ brownish yellow with dusky apex, tarsi dusky to black. *Abdomen* green, varying to yellowish green. Dorsum with irregular, variable, dusky maculations, most commonly resembling Fig. 5. The four large lateral spots in front of the cornicles distinct, dusky to blackish. The seven small, lateral, obtuse tubercles distinct but not conspicuous, mostly broader than long (Fig. 5). Cornicles dusky, swollen at and beyond the middle, a little shorter than hind tarsus, surface smooth, never imbricated (Figs. 8, 12); cauda uniformly pale yellowish from base to apex, the margins black anterior to the distinct median constriction, posterior to which are 3 pairs of long curved setæ; anal plate beset with several similar setæ, 6–8 along posterior margin.

Measurements. (Antennæ measured from base of III to apex of filament). Length of body, head to base of tail, 1.49 mm. (1.39–1.70); greatest width of abdomen, .662 (.61–.696). Antennæ, .97–1.00; III, .335; IV, .155; V, 155; VI (scape) .107, filament, .25. Forewing, 2.0–2.26. Cornicles, 0.12; cauda, 0.155.

Pupa. Color similar to the winged vivipara, with indistinct or no maculations except irregular deeper green marks on mesothorax; wing-pads dusky.

Wingless vivipara. Head dusky yellow with two median dusky spots close together. Antennæ I–II concolorous, elsewhere light brownish, the distal joints becoming dusky; without sensoria except the usual one at apex of V and the group at the apex of the scape of VI. Eyes reddish black or black. Beak extending to or a little beyond mesocoxæ. *Thorax* yellowish green varying to green; a dusky dorsolateral impressed spot on each segment, the one on the mesothorax longitudinal linear, often broken into a row of small spots; thorax otherwise without maculations. Distinct prothoracic lateral tubercle, longer than broad. Legs yellowish-brown except the dusky apex of tibiæ and the tarsi. *Abdomen* concolorous with thorax, without macu-

lations except 4 or 5 small dusky spots forming a dorso-lateral longitudinal row continuous with the thoracic spots, the last distinct spot on about the 5th segment; one indistinct spot just mesal to the cornicle, often absent. Cornicles yellowish with apex dusky, the entire appendage usually not dusky. Whole body lightly pulverulent. Otherwise as in winged vivipara.

Measurements—Length of body, 1.54 mm. (1.35–1.70), width, .609 (.522–.696). Antennæ .584 (.516–.705); III .20, IV, .077, V .09, VI (scape) .077, filament .142. Cornicles, .114, cauda, .172.

Ovipara. This form can be easily told with a hand-lens from the wingless vivipara by the dusky incrassate hind tibiæ with many sensoria and the blackish vaginal plate. Detailed description as follows: Eyes black, rarely reddish black. Legs dusky except the yellowish–brown base of femora and greater proximal portion of fore and middle tibiæ, hind tibiæ dusky, proximal half swollen, 30–40 nearly circular sensoria on both anterior and posterior aspects (Fig. 4). Cornicles dusky. Cauda pale yellowish distally, or entirely dusky; often not constricted. Otherwise similar to the wingless vivipara.

Measurements. Length of body, 1.45 mm. (1.24–1.70), width .565 (.478–.652). Antennæ .553 (.516–.671); III .129, IV .06, V .0774, VI (scape) .077, filament, .122. Cornicles, .112, cauda, .146.

Wingless male. Head and antennæ dusky to blackish. Antennæ (Fig. 17) with average number of sensoria as follows (extremes in parentheses): joint III, 14–15 (11–24); IV, 9–10 (7–14); V, 10–11 (10–14); VI, usual group at apex of scape, often with a single sensorium near its middle. Eyes blackish red; ocelli conspicuous. Beak extending just beyond mesocoxæ. *Pronotum* dusky, lateral tubercle distinct, mesothoracic lobes brownish to dusky, traceable as in Fig. 3; in several specimens they are reduced to irregular dusky marks. Legs dusky to blackish. *Abdomen* dusky yellow, very variable in the tint of yellow, dorsum with irregular, variable dusky marks, usually resembling Fig. 3. Lateral tubercles relatively more pronounced than in the females. Cornicles dusky. Cauda dusky, not constricted (Fig. 19). Otherwise as in winged vivipara.

Measurements. Length of body, 1 mm. (.957–1.04), width, .481 (.430–.550). Antennæ .89 (.72–1.02); III, .258; IV, .142; V, .142, VI (scape) .094, filament, .215. Cornicles, .066; cauda, .113.

Eggs, oval, shining black, .60 x .327 mm. Dissection of many oviparæ collected Oct. 9th, showed that each individual contained from one to eight eggs. The number evidently depended on the size as well as the age, since some large specimens were opened that contained no eggs. The usual number was two to six.

The common black aphid infesting the *Chenopodiums*, as stated above, is entirely distinct from *Aphis atriplicis* L. For the sake of comparison I have drawn the principal systematic differences which may be summarized as follows:

Winged vivipara—Antennæ with many (fully 15–16) sensoria on joint III; 4–5 on IV (Fig. 16). Basal half of costal vein of fore-wing strongly bent anteriorly, bases of 1st and 2nd discoidals always com-

pletely atrophied. Cornicles (Figs. 9, 13), never swollen, but broad at base tapering gradually to apex, distinctly imbricated, black, about 1.5 times length of hind tarsus. Cauda (Fig. 14), stouter, apex more rounded, beset with many stout curved setæ, bicolored, the basal half between the black margins being pale yellowish, while the distal half is dusky to blackish. The prothoracic and 2nd and last abdominal tubercles very pronounced, longer than broad.

Measurements. Length of body, 2 mm. width .98; antennæ 1.25; wing 2.75; cornicles, .20; cauda, 1.5 (averages from several specimens.)

The life history of this black aphid is different from the green species. It never forms galls, usually infests the under side of the leaves or the inflorescence in summer as well as fall, attacks *Rumex* and other weeds besides the *Chenopodiaceæ;* and migrates in the fall from these plants to the wahoo (*Euonymus atropurpurea.*) I observed this migration to the wahoo last fall at Forest Hills where the so-called sexuparæ were depositing oviparous larvæ on the under side of the leaves. These true migrants were precisely identical in structure with the winged viviparæ on *Chenopodium.*

Osborn established the migration of this wahoo aphid (*Aphis rumicis* ? L. = A. euonymi Fab.) in Iowa in 1894. Either this species or a closely similar one migrates between the same hosts in Europe.

It is my privilege to acknowledge Professor Wheeler's kind criticisms in the preparation of this article.

LITERATURE

Aphis atriplicis Fab., Fabricius, Syst. Ent., 1775, p. 737, No. 21, is a distinct species belonging to the Aphis rumicis group.

Aphis atriplicis L., Linnæus, Fauna Svecica (ed. altera), 1761, p. 262, No. 1000. Original description. Sweden. Atriplex littoralis.
=chenopodii Schr., Schrank, Fauna Boica, Vol. 2, Pt. 1, 1801, p. 109, No. 1196. Bavaria, Atriplex patula; descriptions of winged and wingless viviparæ.

Kaltenbach, J. H., Monogr. d. Pflanzenl., 1843, pp. 107–108. Germany. Chenopodium album, Atriplex patula. Descriptions of winged and wingless viviparæ.

Passerini, G., Gli Afidi, 1860, p. 31. Italy.
Ib. Flora degli Afidi Ital., in Bull. Ent. Soc. Ital. 3, 1871, pp. 151, 155. On Atriplex patula and Chenopodium album.

Kaltenbach, J. H., Pflanzenfeinde, 1874, pp. 505, 508. In Germany. Same hosts and habits. Sometimes affects all the leaves of the plants making the leaves appear yellowed and sickly.

Buckton, G. B., British Aphides, Vol. 2, 1879, pp. 87–90, col. pl. 65, figs. 4–7. All descriptions and figures apply to an insect of the Aphis rumicis type except possibly the wingless male and the ovipara which apparently belong to Aphis atriplis L. Notes on the galls and oviposition in the galls. Atriplex sp. England.

Monell, J., Bull. U. S. Geol. & Geogr. Surv. Terr. Vol. 5, No. 1, 1879, p. 25. Common on Chenopodiums at St. Louis, Mo., and at Carbondale, Ill. (Thomas, C. 8th report Ins. Ill., 1879, p. 193.)

Lichtenstein, J., Les Pucerons, 1884, Chap. 4 (La Flore des Aphidiens) pp. 80, 85. Atriplex and Chenopodium.

Oestlund, O. W., Ann. Rept. Geol. & Nat. Hist. Surv. Minn., 14, 1886, p. 47. Minnesota, Chenopodium album. (Ib., Bull. 4, Geol. & Nat. Hist. Surv. Minn., 1887, p. 69.)

Bruner, L., U. S. Dept. Agric. Bur. Ent. Bull. 23 (o. s.) 1891, p. 17. On the beet at Ashland, Nebr. (T. A. Williams.)

Williams, T. A., Univ. Nebr., Dept. Ent., Special Bull. 1., 1891, pp. 6, 10, 12, 20. Nebr. On cultivated beet, Rumex altissimus, Chenopodium album and hydridum.

—chenopodii Cowen., Cowen, J. H., Colo. A. E. S. Bull. 31 (Tech. Ser. No. 1), 1895, p. 119. Descriptions of winged and wingless viviparæ and galls. Colo., Chenopodium album; galls collected in July.

Del Guercio, G., Nuov. Relazioni R. Staz. Ent. Agrar. Firenze (1) No. 2, 1900, pp. 124, 132. Italy. Differential characters in table of species of Aphis. Chenopodium album and Atriplex patula.

Forbes, S. A., Bull. 60, Ill., A. E. S. 1900, p. 430. Illinois. Eggs in dried rolled leaves of Atriplex. Suggests that this species may be identical with Aphis gossypii Glover. (I do not think this possible. The two species have totally different cornicles, those of Aphis gossypii are much longer than the 4th tarsus, incrassate at the base, elsewhere cylindrical, imbricated, black.)

Hunter, W. D., Bull. 60, Iowa A. E. S., 1901, p. 93. Partial bibliography. Hosts, distribution.

Connold, E. T., British Vegetable Galls, 1902, pp. 233–4, pl. 101. England. Atriplex augustifolia and patula. Abundant along the coast and inland. Winged viviparæ emerge in August. All stages including sexes and ova in galls during the fall. (Notes on the insects show that he evidently had colonies mixed with Aphis rumicis (?). Photograph of infested plants showing galls.

Bignell, G. C., Ann. Rept., 72 Roy. Cornwall Polytech. Soc. 1904, p. 24 (Separate) England. Atriplex latifolia.

Luff, W. A., Guernsey Soc. Nat. Sci., Rept. and Trans. for 1905, p. 88. Mention.

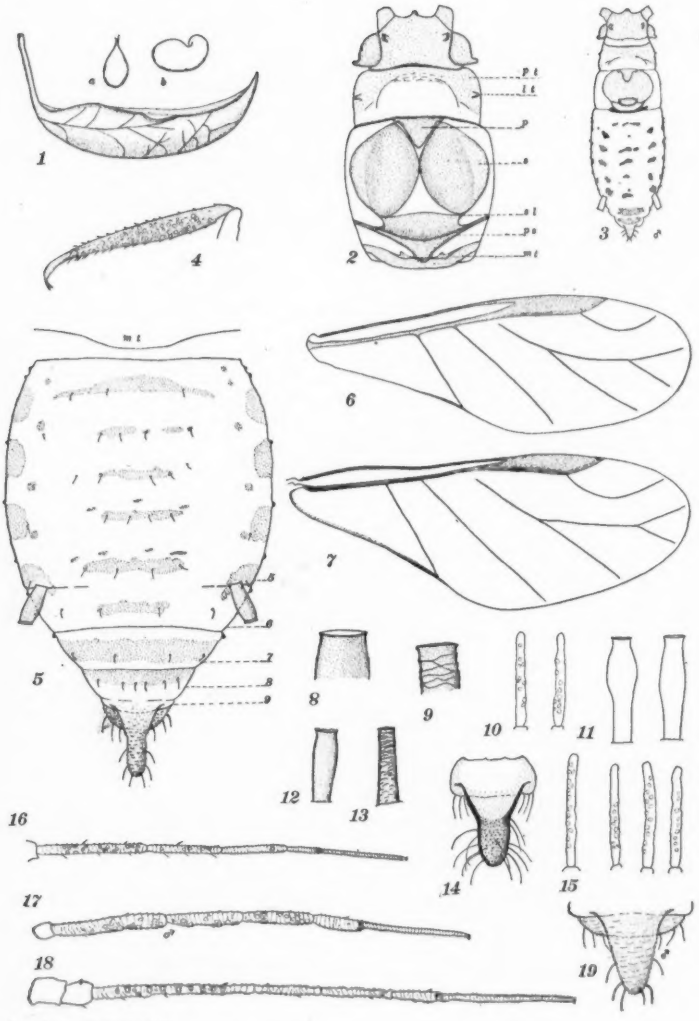
Schouteden, H., Cat. d. Aphides de Belgique. in Mem. Soc. Ent. Belg. 12, p. 216. Belgium; Atriplex, Chenopodium album.

Sanborn, C. E., Kansas Univ., Sci. Bull. Vol. 3, No. 8, 1906, pp. 232, 235, 248, 254, 255. Compiled list of hosts.

PLATE XV.

FIG. 1. Leaf-gall; *a*, *b*, cross-sections.
FIG. 2. Winged vivipara. *pt.*, pronotum; *lt.*, lateral tubercle; *p.*, prescutum; *s.*, scutal lobes; *sl.*, scutellum; *ps.*, post-scutellum; *mt.*, metatergite.
FIG. 3. Wingless male.
FIG. 4. Ovipara, hind tibia.
FIG. 5. Winged vivipara.
FIG. 6. Forewing of same.
FIG. 7. Forewing of *Aphis rumicis* (?).
FIG. 8. Cornicle of *Aphis atriplicis*, distal end.
FIG. 9. Cornicle of *Aphis rumicis* (?), distal end.
FIG. 10. Third antennal joints of *Aphis atriplicis*, winged vivipara, from same individual.
FIG. 11. Cornicles, two variations in the bulge in subgenus *Siphocoryne*.
FIG. 12. Cornicle of *Aphis atriplicis*.
FIG. 13. Cornicle of *Aphis rumicis* (?).
FIG. 14. Cauda of *Aphis rumicis* (?).
FIG. 15. Third antennal joints of *Aphis atriplicis*, from four individuals.
FIG. 16. Antenna of *Aphis rumicis* (?), winged vivipara.
FIG. 17. Antenna of wingless male of *Aphis atriplicis*. (Thickness somewhat exaggerated.)
FIG. 18. Antenna of winged vivipara of *Aphis atriplicis*.
FIG. 19. Cauda of wingless male of *Aphis atriplicis*.

All figures except 1 and 2 made with camera lucida.



Paul Hayhurst del.

HOMOLOGIES OF THE WING VEINS OF THE APHIDIDÆ, PSYLLIDÆ, ALEURODIDAE, AND COCCIDÆ.*

EDITH M. PATCH.

INTRODUCTION AND GENERAL CONSIDERATIONS.

This study of wing venation was undertaken in the hope that it might, for the one small group of Homopterous insects it concerns, supplement in some slight measure other work in wing-vein homologies which has been so vital a problem for insect phylogeny.

The incentive to this study is to be found in "The Wings of Insects" by Comstock and Needham. The choice of the particular group here considered was due to a personal interest in aphids and to the fact that the homologies of the wing-veins of this family were at that time practically untouched.

From the first the work has been under the direction of the Department of Entomology, Cornell University and it is a pleasure to acknowledge the kindness of Professor Comstock during my association with this department as a student, and the patient aid and constant interest and sympathy in my task of Doctor MacGillivray.

To Professor Oestlund at the University of Minnesota is due thanks for the determination of certain species of aphids which are included in this study and for the personal interest with which he has anticipated the results.

Although the work has been entirely under the supervision of the Department of Entomology, Cornell University, the great bulk of the data has been accumulated at Orono, Maine, instead of Ithaca, New York. Several months of each winter during the grogress of the problem, however, have been spent at Cornell in revising data and in such consultation as has insured against certain misinterpretations and other errors due to inexperience in this type of work. At such times the essential points have been in so far as is possible with the greenhouse aphids available, verified while *in residence* in Ithaca, and the work with the Coccidæ and Aleurodidæ has been done in the Entomological laboratory at Cornell University.

Since 1903 each season's collection of aphids in Maine with detailed notes has given me a very fair idea of where to secure

* A contribution from the Entomological Laboratory of Cornell University, and Papers from the Maine Agricultural Experiment Station; Entomology No. 33

given species and upon what plants at any time during the entire season. This has given me a range of from 95 to 105 available species belonging to at least 16 different genera and representing all the types of venation in the entire family.

At the Maine Station two insectaries (one an unheated building of use only during the summer, and one a hot house), have both been available for the segregation of colonies of aphids taken previous to the development of wing pads in order that they could be used at exactly the right time. This made possible a large amount of material safe from the depredations of predaceous insects and parasites, a condition which could never be relied upon with chance collections in the open.

In view of the fact that for the work in hand, no specimen could be used for the study of wing tracheation except during the first few minutes after emergence from the last molt, and that the nymphs could be studied only during a very limited time before the developing wings became much folded in the sac, and that some species gave conspicuously better results than others by virtue of such reasons as the slightly different angle at which the wing pad of certain species are held, or to differences in color, etc.:—it will be evident that the conditions outlined have been most propitious for the study of this particular problem with aphids.

The reasons for approaching the homologies of the wing veins of insects by a study of the tracheæ that precede the veins were so fully set forth and their validity so thoroughly demonstrated by Comstock–Needham* ten years ago that this phase of the question has long been too familiar to call for general discussion here.

However, with each new group of insects studied in this way conditions exist which may have a special bearing on the subject. For instance, an ontogenetic study of the wings of certain insects is not of any value in determining the homologies of the veins‡ in which case entire dependence must be placed on a careful comparison of the veins of the mature wing.

On the other hand with wings so highly specialized by reduction of veins as those of the Homopterous group with which this paper is concerned, the subject is a hopeless one to approach from

---

* The Wings of Insects. Amer. Nat. XXXII and XXXIII, 1898 and 1899.

‡ MacGillivray, A. D., Wings of the Tenthredinoidea 1906. Proceedings of the Nat. Museum. Vol. XXIX, page 574.

the comparison of the veins themselves. What chance is there on the basis of the mature wings alone to homologize except by the merest guess the veins of the Aleurodidæ with those of the Psyllidæ?

Yet fortunately and, in many instances, to my utmost surprise, it was found that practically the whole story of the venation of the group of four families here concerned lies revealed in the preceding tracheation and no one who follows that story closely can fail to recognize in the two surviving veins of Aleurodes for instance the radial sector and cubitus. (See page 122).

One of the simplest but prettiest and most clearly cut of the demonstrations of the value of the tracheation in this connection is to be found by comparing the venation and tracheation of *Chermes* which shows at once that it is the wavering and unstable R_1 which is lacking and not M as has heretofore been considered. (See page 111). And the vagaries of R_1 in the whole group form a fascinating study by themselves.

But exciting and interesting as is the story the tracheæ trace, the quest for the homologies of the wing veins of aphids has lain along a path tedious in many respects and beset with many difficulties.

The tracheæ of aphid wings are very delicate, and when filled with the medium in which the wing is mounted they become invisible, so that many of the examinations and sketches made had to be finished with rapidity, and often many mounts prepared to verify a single point.

The wings studied in connection with this problem were prepared in two ways. Part of them were mounted in glycerine jelly after the method described by Comstock–Needham* and part of them were mounted in xylene damar. With wings so small and delicate as the aphids wings the latter was found in the main more satisfactory. It took the balsam less time to penetrate and render the tracheæ invisible which would have been an objec-

*"In making mounts of this kind our usual procedure was to spread a drop of melted glycerine jelly on a slide and allow it to cool; then to dissect off the wings (generally under water), taking with them just enough of the thorax to include the basal attachments of the tracheae; then to place these wings upon the solidified glycerine jelly on the slide; then to lower upon the wings a heated cover glass, causing the jelly to melt enough to envelope the wings; and then to cool the mount speedily on a cake of ice, a marble slab, or in a draught of cold air. Rapid cooling is imperative, for in melted glycerine jelly the tracheæ soon become filled and the smaller ones are then invisible." The Amer. Nat. Vol. XXXII, page 45.

tion except that even the balsam mounts remained usable for a sufficient time to secure camera lucida drawings of the points in question. In preparations for photomicrographs the glycerine jelly mounts were better.

After comparing the two methods the balsam mounts were used almost altogether as they were quicker and simpler to prepare and a much larger proportion of usable mounts were made in this way.

The wings of freshly emerged aphids were severed from the body together with a portion of the thorax, to preserve the basal part of the tracheæ and to block to some extent the penetration of the balsam.

In some species, where the shape of the body and the angle at which the wings are set permitted it, the aphid itself with wings attached was mounted after beheading the insect and puncturing the tip of the abdomen. The legs had also to be removed. The pressure of the cover glass in these mounts generally forced the body fluids from the openings at the two extremities and often excellent tracheal preparations were secured in this way. It could be applied only to a limited number of species, however.

Only wings of freshly emerged aphids are available for the study of the wing tracheæ, as before the wings are hardened enough for the first flight, the tracheæ have become either entirely invisible or so nearly so that they are useless for the questions in hand. It thus becomes necessary to select the individuals in the first few minutes after molting. This can readily be done by taking the palest insects while the wings are yet white, that is, before they begin to become transparent. An abundance of material was kept on hand by the collection of large colonies of aphids whenever any were found, the wing pads of which indicated that the final molt was approaching.

It was more difficult to secure the wing pads at the critical moment. The wing pad of the aphid nymph is not only small but it is relatively thicker and softer and narrower than those of many insects and the developing wing is for the most part so crumpled that the courses of the tracheæ are impossible to follow. So soft is the tissue of the nymphal pad and so loose do the tracheæ lie within it, that the slighest pressure is likely to misplace them or rupture them, and render the preparation useless. By selecting the nymphs of such species as had the flatter wing pads,

the best results were obtained. However, none of the aphids are so easy to manipulate for the tracheation of the wing pads as are the flat padded psyllids.

* * * * *

Although the possibilities of interesting features of wing tracheation of the aphids were by no means exhausted with any species; for the problem at issue,—the homologies of the wing veins,—no point was left in question. Wings of more than two thousand of newly emerged aphids were examined. Where possible a single point was verified for all the variations of wing types from *Lachnus* to *Chermes*. Where a point arose that certain species showed better than others it was exhaustively studied by making numerous mounts of those species which had any bearing upon it.

As for the range of material used, approximately 100 species belonging to 16 genera were drawn upon. Many of these were discarded after a few mounts,—as for instance after the condition for the genus *Aphis* was clearly ascertained other species of this genus did not give additional data. Many species were found unsatisfactory to work with by reason of size, density of color or other conditions and were discarded after a few trials.

The genera from which most of the data were accumulated and in all of which the tracheation was demonstrated repeatedly and conclusively, are Lachnus, Melanoxanthus, Callipterus, Chaitophorus, Myzus, Macrosiphum, Rhopalosiphum, Aphis, Schizoneura, Mindarus, Pemphigus, Tetraneura, Hamamelistes, Chermes and two new genera still in manuscript. These genera present practically the whole variation of the types of aphid venation from the more generalized to the more specialized.

The more logical presentation of the four families considered in this paper would be in the following order,—Psyllidæ, Aphididæ, Aleurodidæ and Coccidæ, but as the problem was undertaken primarily for the Aphididæ and as the investigation was devoted for the most part to them, the part dealing with the aphids is presented first. The work with the other families, though sufficient to indicate the homologies of the veins, has been so much slighter in amount that it seems more fitting to give secondary place to the Psyllidæ even though this necessitates a break in the systematic sequence.

THE COURSE OF A VEIN.

In the following pages the "course" and the "free part" of veins are frequently mentioned. By the free part of a vein is meant all that portion that is not coalesced with any other vein. As for instance in Fig. 36, the free part of Cu_2 is all that portion of Cu_2 between the point where it separates from Cu_1 and the margin of the wing.

As to the course of the vein it has been convenient to consider each of the branches of any vein as extending from the base to the margin of the wing, as is made plain by the following quotation:*

"If radius and its five branches be taken as an example, the stem part, always designated as R, would be considered as being a combination of all the branches of radius, or as $R_{1+2+3+4+5}$, which divides into R_1 and R_{2-5}. In like manner the stem of the radial sector would be considered as being a combination of all the branches of the radial sector, or as $R_{2+3+4+5}$, which divided into R_{2+3} and R_{4+5}, and these in turn into R_2 and R_3, and R_4 and R_5, respectively. So that in tracing out the course of any of the branches of radius by drawing a pencil along them, as R_4, beginning at the base of the wing, we would pass first over the stem of R, then over the stem of the radial sector, then over R_{4+5}, and finally over the free part of R_4."

COALESCENCE OF TRACHEÆ.

A comparison of the tracheation of the wing pad of an aphid nymph with that of the wing of the recently emerged aphid of the same species reveals the fact that there are fewer basal tracheæ in the later than in the earlier stage, although the terminal branches are the same in number. For instance, there are four tracheæ which branch from the body trachea in the nymphal wing pad of *Schizoneura rileyi* (fig. 21) and only two tracheal stems at the base of the newly emerged wing of the same species (fig. 22). Similarly as there are four tracheæ at the base of the nymphal wing pad of the species of *Aphis* which I have studied and of *Callipterus ulmifolii* while there are but two basal tracheæ in the newly emerged wings of these same species, this is shown to be the normal condition for the family in the more generalized genera. In the nymphal wing pad of *Mindarus* (fig. 18) three

* MacGillivary, A. D., Wings of Tenthredinoidea. Proc. U. S. Nat. Museum Vol. XXIX, page 576. 1906.

of these tracheæ unite before they reach the body tracheæ, approaching the condition of the mature wing.

This change in the condition of the corresponding tracheæ at different stages has been designated in this paper as the "coalescence" of tracheæ, as this term seems to express the relation of the tracheæ of the mature wing to those of the nymphal wing pad. This sort of coalescence of tracheæ is a constant factor in the aphids, not alone as to the main tracheal stems but a similar tendency is shown in the branches of the tracheæ. For instance notice that the medial trachea in figure 21 branches desidedly nearer the base of the wing than the medial trachea in figure 22, these branches being coalesced to much nearer the margin of the wing than in the earlier stage.

How or when this coalescence takes place the writer has as yet made no attempt to ascertain. No pains has been spared, however, in accumulating evidence that it does occur, or in making sure that it is an actual union of tracheæ and not an approximation. A 1–6 objective was usually sufficient for the examination of the cases in question. Where it was not, an oil emersion was used. The manner and time of the coalescence is a mystery well worth solving but it is only the *fact* of this coalescence and not its method which has any bearing on the present problem—the homologies of the veins. However, it is a problem which the writer hopes to undertake in the near future.

Besides the normal coalescence of the basal portions of medial, cubital, and the first anal tracheæ just described, very rare instances of abnormal coalescence occur. Figure 2 shows a wing of *Melanoxanthus* in which the radial, medial and cubital tracheæ are anastomosed for a considerable distance.

Attention is also called to Plate XIX, which shows three unusual examples of tracheation. Normally the forewing of *Chermes* has two basal tracheæ as in the more generalized genera, and as is shown in figures 24 and 28. But in this highly specialized genus the tracheation seems to be unstable. Figure 26 shows an instance of anastomosis similar to that in figure 2, while figure 27 represents a single tracheal stem at the base of the wing, a condition which approaches the normal condition of the hind wing of *Chermes* (fig. 30.) On the other hand figure 25 records an instance where the first anal trachea is separate from the common stem of the medial and cubital tracheæ to the base of the wing, giving in this case three basal tracheæ.

In the study of the tracheation in the Psyllidæ the writer has been confined to a single species, and we have here even a more striking degree of normal coalescence of tracheæ than in the Aphididae. For instance, as is shown in figure 33, the seven tracheæ are distinct to the body trachea in the nymphal wing pad, while figure 34 records the normal tracheation of the freshly emerged wing, the three most important tracheæ, the radial, medial, and cubital tracheæ, are coalesced into a common stem at the base, and for a considerable distance the medial and cubital tracheæ are stalked after the radial trachea has separated from them.

We have, then, a very striking difference in the relation of the tracheæ of the nymphal wing pad and those of the freshly emerged wing, in both of these families of insects.

COSTA AND SUBCOSTA OF APHIDIDÆ.

The costal vein extends along the cephalic margin of the wing. No trachea precedes this vein in the freshly emerged wing.* Neither is a costal trachea present in any nymphal wing pad of the species examined by the writer. Further, no evidence of a vestigial costal spur from the body trachea is to be found in the several species examined for this point. Perhaps the most striking evidence of a costal vein aside from the stiffening of the costal margin is the fact that in severing the wing from a freshly killed aphid, the yellow body fluids frequently flow into this vein and extend along to about the region of the stigma (fig. 4).

In like manner no trachea precedes the vein subcosta in any species examined of the sixteen genera (see page 105) of aphids from *Lachnus* to *Chermes* which I have studied for this point. No item in this work has been more carefully investigated than the possibility of a subcostal trachea.

Indications of such a trachea have by no means been lacking. For instance, the fold of the vein subcosta appears very early in the freshly emerged wing (long before the other veins) and is therefore frequently the only vein indicated at the time the tracheæ are visible. For many mounts of many species this forming vein resembles a tracheal line closely enough to be mistaken for one unless exceedingly great care is taken to secure

* Comstock and Needham. Wings of Insects. Page 858. "* * * there are often channels present which do not contain tracheæ. This is oftenest true of two large channels at the lateral margins of the wing. Of these the costal remains abundantly lined with cells, which ultimately form the strong costal vein. Its trachea is often atrophied, probably owing to the disadvantageous position of its base in relation to air supply, as we have hitherto indicated."

wings immediately after emergence. Handlirsch* thus mistook this forming vein for a trachea in his preparation of *Schizoneura lanigera*.

Wherever there has been the slightest chance that a subcostal trachea might be present, exhaustive investigation has been made until no possible doubt of its absence remained.

Again, for some species, one of the secondary branches of the radial trachea near its base might easily be mistaken for a subcostal trachea so far as its position goes. *Chermes pinifoliæ* (fig. 26) serves as an illustration of this. But these secondary branches are very variable even for the same species and after examining large series of mounts little difficulty is experienced in distinguishing the tracheæ of the main veins from secondary branches.

The only trachea found during the whole time possible to interpret as the subcosta was a single mount out of hundreds of *Mindarus* (*abietinus* Koch?) where an exceedingly short branch from the radial trunk near the base occurred, larger than the ordinary secondary tracheæ. This may be an abortive subcostal not entirely atrophied. Or it may be merely an abnormality.

This species of Mindarus, collected in great abundance from Balsam fir in the vicinity of Orono is apparently the same as abietinus Koch. But as it has not yet been compared with specimens from Europe it is given in this paper accompanied with a question mark.

Another opportunity for confusing a branch of the radial trachea for a subcostal trachea is found in wings where the path of the tracheal branch of radius chances to coincide with that of the newly forming subcostal vein. Such a case is shown in the tracheation of *Pemphigus acerifolii* (fig. 12) where the trachea follows the stigmal margin that the subcostal vein is later to bound. But the branches of the radial trachea are quite as likely to cut directly across the path of the forming subcostal vein as to coincide. *Chermes abietis* (fig. 24) will illustrate this.

The point, however, which gave me most trouble was the fact that very frequently the fold in the wing caused by the forming subcostal vein bent the branches of the radial trachea to such an extent that their connection with the radial trachea was obscured and a series of tracheal branches resulted which had every appearance of rising directly from the region of the subcosta.

* Handlirsch, A. Fossilen Insekten. Plate VIII. Fig. 9.

The absence of a costal trachea is by no means unusual.* The aphid wing is characterized by the reduction of tracheæ and the loss of the subcostal trachea is only one more step in the general trend of reduction. What the aphid lacks in main tracheal trunks, however, it makes up in secondary ramifications, and a glance at the tracheation of *Chermes abietis* (fig. 24) will show that the absence of costal and subcostal tracheæ does not indicate that this portion of the wing is untracheated. Perhaps the abundance of secondary tracheæ explains the absence of unnecessary costal and subcostal tracheæ. At any rate they might in some cases be mistaken for one of these main tracheæ. Refer again to *Chermes abietis* (fig. 24) where the ends of the radial branches are so interwoven as to have the appearance of a continuous subcostal trachea. And where the channel of the subcostal vein hides the radial connection, we have frequently the occurrence of what appears to be a strong subcostal trachea with branches extending toward the radius. Further, in case the radial connection of all these tracheæ, except a single one near the base of the wing, is obscured, as sometimes happens, there is, to all superficial appearances, a clear indication of a strong subcostal trachea.

Altogether the absence of the subcostal trachea was one of the most troublesome points to establish. Each clue was followed, however, until the evidence was absolutely conclusive.

Although no subcostal trachea is present, there seems to be no other conclusion except to consider that the vein subcosta is present in the large main vein channel of the wing, and extends from the base of the wing to the stigma where it approaches the margin of the wing. Indeed it seems not at all unlikely that this stiff vein fold at the base of the aphid wing is responsible for the atrophy of the subcostal trachea. The radial trachea from its position can elude the pressure and run alongside, but this obstruction alone would seem sufficient to explain the loss of the subcostal trachea in the Aphididæ.

RADIUS OF APHIDIDÆ.

The tracheation of *Myzus cerasi* (fig. 3) gives a fairly typical two-branched radial trachea. This type persists for the family of Aphididæ except in the Chermesinæ where this trachea is not branched. This trachea is one of the two main tracheæ which enter the wing, and from the phylogenetic standpoint the chief

* See Footnote, page 108 (Costa and Subcosta).

interest concerning it is centered in the cephalic branch, or the trachea preceding vein R_1.

In the case of two widely separated Hemiptera, a Cicada and a Coreid, this trachea was found to be but weakly developed in the nymphal wing pads,* being apparently crowded out by the strong subcostal trachea, and it was not succeeded by a vein,—the vein R_1 being completely absent in these two insects.

With the aphids no such crowding of the radial trachea occurs, for, as has been shown, the costal and subcostal are both absent.

It is, however, of great phylogenetic interest to find that in the tracheation of the aphids, the weak character of this same trachea (that is the one preceding vein R_1) is evident. In *Lachnus*, probably the most generalized genus in the family, this branch is scarcely to be distinguished from the secondary branches of the radial trachea and is emphasized chiefly from the fact that it is succeeded by a vein R_1 (fig. 1). And in all of the generalized genera it is characterized by a wavering and uncertain course. It is consistent with this general tendency to find that this is the tracheal branch which if it appears at all in the specialized Chermesinæ is so weakly indicated as to become indistinguishable from the secondary branches and loses its significance as it is not succeeded by a vein, vein R_1 being absent in the Chermesinæ.

The wings of the Chermesinæ are at a glance conspicuously of a different type from those of the more generalized aphids, and this difference in venation has heretofore been interpreted as due to the absence of media (the "third discoidal"). Especial attention is called, therefore, to figures 28 and 29. These are two drawings made of the same identical wing of *Chermes pinifoliæ*,—figure 28 drawn immediately after mounting when most of the tracheæ showed, and figure 29 drawn from the same mount 24 hours later when the tracheæ had cleared and become invisible and the veins are apparent instead. These drawings indicate the character of the difference between the *Chermes* venation and that of the more generalized genera. R_1 has disappeared and Rs, losing its characteristic curve, lies along the caudal margin of the stigma. Media, apparently to replace the position and function thus deserted by the radial sector, migrates forward to approximately the position which the "stigmal vein" or radial sector occupies in the generalized genera. This is an interpretation which could in no wise be settled except by appeal to the trachea-

* Comstock and Needham. Wings of Insects. pp. 245—251.

tion, and it is perhaps as pretty an illustration as can be found of the conclusive evidence which tracheation can sometimes bear in a doubtful case of venation.

The same condition is shown in *Chermes abietis* (figs. 24 and 25).

Although the radial trachea has no main branches except R_1 and the sector, this trachea very frequently as is the case of the other tracheæ, bears a great number of secondary ramifications. These secondary branches are omitted in many of the drawings accompanying this study as they are the first to clear and become invisible,* and were frequently neglected when first attention was concentrated on other points. However, a glance at *Chermes abietis* (fig. 24) and *Lachnus strobi* (fig. 1) representing the genera at the extreme ends of the Aphididæ show the general condition of these radial ramifications which are further treated under the discussion of the subcosta (see page 108).

With an understanding of the tracheation, little explanation is required for the vein radius. Except for the *Chermesinæ*, the free part of R_1 forms the caudal boundary of the stigma and extends to the margin of the wing. The radial sector originates in the vicinity of the stigma and curves strongly to near the tip of the wing. The main stem of radius extends from the junction of these branches to the base of the wing in a line about parallel to the subcosta,—forming indeed a part of that strong main composite vein channel of the wing.

In Chermesinæ, radius is unbranched, as has been explained, and takes a straight course from the base of the wing to the extremity of the stigma. A double adjustment takes place here. Correlated with the loss of R_1, which in the more generalized genera bounds the stigma along its distal edge, is a straightening of the caudal margin of the stigma and a straightening of the course of the radial sector so that the radial sector runs along the edge of the broadened stigma in this type of wing (figs. 31 and 32).

MEDIA OF APHIDIDÆ.

For a correct interpretation of media an understanding of the tracheation is necessary. The freshly emerged wing of *Myzus cerasi* (fig. 3) gives a fairly typical tracheation for the more generalized wings. The medial trachea will here be seen, as is true for all the genera of Aphididæ, to be the second of the two main tracheæ to enter the wing from the body cavity. This trachea

* See discussion of preparation, page 103.

lies uniformly parallel to the radial trachea, usually separated from it by an appreciable distance, though often touching it, but not, except in rare instances,* really coalesced with the radial trachea. As we approach the wings most specialized by reduction of tracheæ, we come first to *Schizoneura* (fig. 22) and *Mindarus* (fig. 19) as examples of the medial trachea with but two branches, and then to such wings as those of *Pemphigus*, *Tetraneura*, *Hamamelistes* and *Chermes*, where media is unbranched. The migration of the medial trachea to approximately the position occupied by the radial sector which in turn migrates to meet the margin of the stigma, is characteristic of the Chermesinæ, and has just been discussed under the treatment of radius.

The tracheation of the adult wing, however, does not suffice to make perfectly evident the relation of media to cubitus. For instance, so far as has yet been demonstrated, what is here interpreted as M_3+_4 (fig. 22) might perhaps be understood as cubitus coalesced with media as Vickery† has explained it, or what is here interpreted as cubitus might be homologized as a branch of media as Handlirsch‡ has done. Fortunately the tracheation of the wing pad of the nymphs of certain species make this point entirely clear. Reference to the nymphal pad of *Schizoneura rileyi* (fig. 21) gives an unmistakale demonstration concerning the point at issue. Four main tracheæ are seen to be separate to the place of connection with the body trachea. These are the forerunners of radius, media, cubitus and the first anal vein. The two-branched media and the unbranched cubitus of *Schizoneura* are thus clearly seen to be preceded by distinct tracheæ separate to the base of the wing pad, and the relation of media to cubitus in the mature wing becomes at once apparent and the degree of basal coalescence evident.

After the foregoing discussion of the tracheation little remains which needs to be said concerning the vein media. For approximately one-half the length of radius media is coalesced with R + Sc.‖ and nearer the base of the wing similarly with the proxi-

* For discussion of coalescence and anastomosis of the tracheæ, see page 106.

† Vickery, '08, page 9. Figure 2.

‡ Handlirsch. Die Fossilen Insekten und die Phylogenie der Rezenten Formen. 1906–08. Taf. VIII, figures 9 and 10.

‖ "The figures show that in some cases what appears as a single vein is formed about two closely parallel tracheæ. This is shown in the case of the bases of the second and third principal tracheæ, counting from the costal margin of the wing, the radial and medial tracheæ. This illustrates a fact of frequent occurrence, that what appears to be a single vein may be formed by the coalescence of two primitive veins." Comstock–Needham, Wings of Insects, p. 48.

mal portions of cubitus and the first anal vein. The free part of media occupies about the center of the distal half of the wing. Its maximum number of branches is three, —M_1 and M_2 and M_3+_4 (fig. 8). The first step at reduction is in such wings as *Schizoneura* and *Mindarus* where M_1 and M_2 are coalesced, giving a two-branched media M_1+_2 and M_3+_4 (figs. 20 and 23). These two branches in turn are coalesced, resulting in the unbranched media ($M_1+_2+M_3+_4$)* in the wings having the most reduced venation.

The connection between the free parts of media, cubitus and the anal vein and the composite main vein is frequently broken, on account, probably, of the strong ridge in the wing caused by this vein. This part of media being in the central portion of the wing is not, apparently, so necessary to the strength of the wing as the veins on either side, and starting from the broken basal connection media is found in various degrees of atrophy, in some species one-third to one-half of the base of the free part of media being lacking (fig. 17).

CUBITUS OF APHIDIDÆ.

Cubitus is present in all the genera of Aphididæ and in all of them unbranched.

The tracheation of the freshly emerged wing and of the wing pad explains cubitus and its relation to the other veins.

Attention is called to figure 22, *Schizoneura rileyi*, which gives a fair illustration of the cubital trachea. Its basal portion is coalesced with those of the medial and anal tracheæ. In most wings the free portion of the cubital trachea originates about midway between the medial and first anal tracheæ. In some instances however, the cubital trachea runs along parallel with the medial trachea for some little distance. Figure 9, a mount of a newly emerged hind wing of *Macrosiphum pisi*, is an unusual instance even for the species in question, where the cubital trachea runs parallel with the medial to almost the base of the wing before it becomes coalesced. On the other hand, in the wing of *Hamamelistes spinosus* (fig. 15) a greater degree of coalescence has taken place and the cubital and first anal tracheæ branch from the medial on a common stem, and proceed some little distance before separating.

* See page 106 for a discussion of the course of a vein.

The tracheation of the wing itself, however, is not sufficient to define cubitus beyond question, and numerous mounts of nymphal wing-pads were examined with this end in view. Perhaps the most satisfactory is that of *Schizoneura rileyi* (fig. 21) in which a portion of the body trachea is seen with four main wing tracheæ, the fore-runners of radius, media, cubitus and the first anal vein.

Cubitus is here clearly shown in its relation to media and the first anal and the peculiar complications of the venation of the adult wing are thus explanable as coalescences with media on the one hand or the first anal on the other. *Schizoneura rileyi* was the only species in which the writer has succeeded in getting the connection of these four nymphal wing tracheæ with the body trachea, but mounts of *Callipterus ulmifolii* showed four main tracheæ distinct to the base of the pad, as did also mounts of *Aphis* sp. In the last nymphal stage there is a tendency, in some species at least, for the basal portions of the medial, cubital and first anal tracheæ to become coalesced, giving the two main tracheal stems of the mature wing. This is shown in a wing pad of the last nymphal stage of *Mindarus* (fig. 18) where the four main tracheæ are distinct nearly to the base of the pad where three of them become coalesced before reaching the body trachea.

The vein cubitus so closely follows the cubital trachea that a further discussion concerning it is not necessary.

THE ANALS OF APHIDIDÆ.

The same mounts which explain cubitus show just as clearly the first anal and its relation to the other veins. We have then the unmistakable homologies of four of the wing veins of Aphididæ traced in the courses of the tracheæ of the freshly emerged wings and the wing pads of the nymphs: the "first discoidal" being the first anal, the "second discoidal" being the cubitus, the "third discoidal" or "cubital vein" being the media and the "fourth discoidal" or "stigmal vein" being the radial sector.

This seems enough to ask of the tracheæ of a highly specialized wing, but they do tell even more. They give constantly the second anal which appears in the freshly emerged wings for all the genera studied by the writer, as a delicately marked and fairly regularly placed trachea. No vein is formed about this trachea so that it has no other significance for the venation than to help determine that the anal vein here homologized as the first anal

has not been so homologized without tracheal evidence that it is not the second or third anal,—a statement further elucidated by the appearance of a third anal trachea in many freshly emerged wings. Figures 1 and 3 and others give the second anal trachea in its characteristic position, and figures 2, 4, 6 and others give a few of many mounts showing the third anal trachea also. These last anal tracheæ are among the first of the tracheæ to become invisible, so that in drawings made with other points in view, they are frequently not indicated, as they had cleared before the other points at issue had been finished.

The presence of the second and third anal tracheæ in the nymphal wing pad has not been established in those species of aphids in which the nymphs were studied. What the history of these tracheæ is, then, previous to their appearance in the recently emerged wing is not yet ascertained.

THE HIND WING OF APHIDIDÆ.

The hind wing of *Chaitophorus populicola* (fig. 7) will serve as an illustration of the tracheation of the hind wings of the more generalized genera. In figure 9 of the *Macrosiphum pisi* the four tracheæ are distinct to very near the base of the wing. Usually a greater degree of coalescence has taken place even for this species.

By referring this wing to the front wing of *Chermes* (Plate XIX) we can readily homologize the unbranched radial trachea, the simple medial trachea, the cubital trachea and the first anal. Like the second anal of the fore wing, the first anal of the hind wing appears only as a trachea and is not followed by a vein.

The same tracheæ occur in the other more generalized genera, and also in *Pemphigus* (fig. 13) where the front wing is specialized by the reduction of veins in media. When we reach *Chermes* (fig. 30), however, we find, in spite of the wealth of secondary tracheæ, only the radial and medial tracheæ marking the courses of succeeding veins and these are coalesced at the base.

The venation of the hind wing is, then, homologized, as follows: the marginal costa and the very faint subcosta, both of which, due to the lack of mechanical necessity found in the front wing, are not well developed; the radius represented by the radial sector only; the media always simple; and in the more generalized genera, cubitus. The venation of *Tetraneura* (fig. 17) is of interest. The front wing has the venation of *Pemphigus* and

the hind wing lacks the cubitus and is, therefore, a step in the direction of *Chermes*.

Although we find the same veins in the hind wings of *Macrosiphum solanifolii* (fig. 8) and *Pemphigus acerifoliæ* (fig. 13) for instance, these two wings appear different on account of the difference of position of the veins. The radial sector takes the same course in both wings, but the free part of cubitus originates much nearer the base of the wing in *Macrosiphum* while usually in *Pemphigus* cubitus is coalesced with media to the point where media branches off from the course of radius. This peculiarity is correlated with a similar manifestation in the front wing of *Pemphigus* and is doubtless due to the long narrow wings of this genus.

In *Chermes* (figs. 30 and 31) as was stated in the discussion of the tracheation, only veins radial sector and media are represented, and the hind wing of *Phylloxera* (fig. 32) has retained only the radial sector.

PSYLLIDÆ.

The tracheation of the psyllid wing is instructive both because it throws light upon the interpretation of the venation of the psyllid wing and because it bears strong additional evidence in support of the conclusions arrived at for the aphid wings.

Fig. 33 gives the tracheation of the fore-wing pad of the nymph of *Psylla floccosa* Patch. It will be seen by reference to this that there is no coalescence for these tracheæ at this stage. They all branch separately from the body trachea. There are seven tracheæ: the costal; a short trachea lying at the very margin of the wing pad; the unbranched subcostal extending in a line about parallel to the costal margin of the pad and lying very close to the costal trachea at the base; the radial, terminating in two long branches, the forerunners of R_1 and Rs; the two-branched medial; the typical two-branched cubital; and two anal tracheæ.

This comes surprisingly close, for a wing so highly specialized, to the hypothetical type of Comstock–Needham.

The newly emerged wing shows a decided change in the appearance of the tracheæ, but the change is due to basal coalescence instead of any radical change in the number or branching of the tracheæ.

The tracheation of the freshly emerged wing of *Psylla floccosa* (Fig. 34) shows the degree of this change. The costal trachea has

disappeared as is frequently the case.* The subcostal and second anal tracheæ have migrated to very near their respective margins of the wing, but are both distinct. The first anal, a slender but distinct trachea, follows the course of the claval suture. The proximal portions of the radial, medial and cubital tracheæ are coalesced into a common stem at the basal fourth of the wing. This main stem divides into two tracheæ, the radial and the common stem of the medial and cubital. The latter soon separates again into the free portions of the medial and cubital tracheæ.

There is a greater degree of coalescence in the tracheation of this psyllid wing than occurs in that of the aphid wing as the radial trachea is always (except in very unusual variations as cited, page 107) separate to the base of the freshly emerged aphid wing.

The venation of *Psylla floccosa* (fig. 36) coincides with the tracheation of the freshly emerged wing very closely. Subcosta strengthens with the costa the cephalic margin of the wing. The second anal in a similar way reinforces the anal margin at the base. The first anal is so delicately traced along the claval suture that it cannot function as a strengthening rod in the wing as do the other veins. Indeed it has frequently been considered not a true vein.

Radius, media, and cubitus share about equally the burden of strengthening the wing. They are coalesced as a common main stem at the base. The relation of media and cubitus is similar to that of the same veins in the wing of the aphids and this typical two branched cubitus bears further evidence of the correctness of the interpretation of cubitus in the aphid wing.

R_1 responds to the mechanical necessity for strengthening the front of the wing. It is the only vein present in this region and upon it falls the burden as well as the approximate position usually assumed by the subcosta in many insect wings. Rs is a strong vein and reaches the margin near the apex of the wing.

The tracheation of the freshly emerged hind wing of *Psylla floccosa* resembles that of the front wing closely. (Fig. 35). The subcostal and second anal tracheæ lie near their respective wing margins, as in the front wing. The first anal trachea occu-

* "Its trachea is often atrophied, probably owing to the disadvantageous position of its base in relation to air supply, as we have hitherto indicated." Comstock–Needham: Wings of Insects, page 858.

pies the same position as in the front wing. Similarly there is a common stem of the radial, medial and cubital tracheæ. The medial trachea, however, is unbranched, and the tracheal branch preceding R_1 is wanting.

The loss of R_1 is significant. This vein is one of the least stable of the Hemipterous wing veins. Its complete absence has been established for the Cicada and a Coreid.* In the front wing of the aphids R_1 was seen to be preceded by a wavering trachea in all the subfamilies except the Chermesinæ where the vein R_1 is altogether lacking. In the hind wing of none of the aphids does either the vein R_1 occur, or the corresponding trachea.

In the front wing of the psyllid and *Aleurodicus* alone for this group is R_1 a strong vein and here it is evidently the response to the mechanical necessity not otherwise provided for. Subcosta is wanting and, as the only vein present in this portion of the wing, the burden of support falls upon the radius.

It is exceedingly interesting to find the condition of R_1 as predicted for the Hemiptera† on the basis of the Cicada and Coreid, fulfilled in this group of highly specialized Homoptera.

It is interesting, too, to find the same veins, vein for vein, appear in the wing of the psyllid that we have in the wing of the aphid—the most striking difference is a very slight one,—the cubitus branched in the psyllid and unbranched in the aphid. There is experienced no difficulty, as has been seen, in homologizing either the aphid or the psyllid veins independently of each other but the fact that in doing so the conclusions arrived at with each support and bring additional evidence for the other should in no wise be disregarded.

The fact that the costal margin of the psyllid wing is strengthened in one of two distinct ways (1) by a stigma and (2) by R_1, is very well brought out in the five psyllids which have been selected to represent the venation of this family. Of these *Euphalerus nidifex* Schwarz‡ (fig. 38) would seem to be the most generalized type so far as the radial region is concerned, R_1 in this wing extending to near the tip of the wing as the trachea preceding R_1 does in the nymphal wing pad of *Psylla floccosa* (fig. 33). In *Pachy-*

* Comstock and Needham: Wings of Insects. Page 245.

† Comstock and Needham: Wings of Insects. Page 245.

‡ For an opportunity to study and figure the wings of E. nidifex and A. mori, the writer is indebted to Dr. L. O. Howard, who kindly loaned specimens of these species for this purpose.

psylla c. mamma Riley (fig. 39) the tip of R_1 has migrated slightly toward the middle of the costal margin. In both these wings the space from the base of the wing to the tip of R_1 is evidently too long to bear the strain of flight without further strengthening. This needed reinforcement occurs in the presence of a more or less pronounced stigma the proximal edge of which is margined by a ridge which is in some species so clearly defined as to be frequently figured as a vein.

As the tip of R_1 approaches the middle of the costal margin as in *Anomoneura mori* Schwarz (fig. 40) and even more in *Psylla floccosa* (fig. 36) the need of the stigma is removed as R_1 strengthens this portion of the wing margin.

The wing of *Trioza* (fig. 37) shows an extreme case of the migration of R_1, this vein being here scarcely longer than the stigmal ridge in *Pachypsylla* and in about the same position. Correlated with this condition are other striking departures from the more generalized psyllid wing, perhaps the most conspicuous being the origin of the free parts of media and cubitus at approximately the same point as the origin of the free part of radius,—the common stem M+Cu present in most psyllids being lacking in *Trioza*.

The wing of *A. mori* is in one respect most unusual for the family, and that is in the branching of the radial sector. This is the only instance in the four families discussed in this paper where the radial sector is branched, and it throws additional evidence on the interpretation of this vein as the sector. It should be stated in connection with the discussion of figure 40, that the venation here shown may possibly be not normal for this species. The writer had access to but a single specimen and in this the radial sector of the wing on one side bore five branches as figured while the radial sector of the other side was six branched.

The purpose of this study in wing tracheation has had the vein homologies as a goal and is not intended to enter into systematic discussions. However, since the systematists of the Psyllidæ build their tables largely upon the basis of the wing veins,* it is apparent that it would be more satisfactory to apply

* Löw. Verh. g–b. Wien XXVIII.
Maskell: Transactions of the N. Z. Institute Vol. XXII, 1889, page 158.
Frogatt: Australian Insects.
Kuwayama: Trans. of the Sapporo Nat. Hist. Soc. 1907–08.

a terminology which has the same significance for not only the closely related families of Aphididæ, Aleurodidæ, and Coccidæ, but the other insect orders as well.

For instance it would certainly seem more convenient to say "M + Cu is longer than the stem of R" than to resort to the more tortuous statement of Maskell*: "the stalk of the lower branch (cubitus) of the furcation of the primary vein is longer than the stalk of the upper branch (subcosta)."

At present the veins in the figures of the psyllid wings are indicated by arbitrary letters or figures with no necessary relation to symbols used by the same author for any other psyllid wing or to those of any other author for the same wing. This haphazard arrangement of lettering or numbering the figures of psyllid wings increases the confusion caused by the fact that the veins themselves are cumbered with such a system of nomenclature as the following:

"Stalk of cubitus, lower branch of cubitus, lower fork of lower branch of cubitus, upper fork of lower branch of cubitus," etc.

But by the use of a uniform system of wing terminology the abbreviation of the names of the veins become the natural and inevitable symbols to use for lettering the figures of the wings, and no confusion arises in associating Rs of the figure, for instance, with the radial-sector of the text.

The relative simplicity, ease of abbreviation and uniformity of such a system of terminology is recommendation enough aside from the homological significance it bears.†

As is stated in the discussion of Redtenbacher's homologies (see page 125) except for his interpretation of the alternate concave and convex veins his terms for the psyllid veins are in the main those applied in this present paper upon the basis of the tracheation.

ALEURODIDÆ.

Four fine but distinct tracheæ are present in the freshly emerged wing of Aleurodes *sp.*,—the costal, subcostal, radial and cubital tracheæ (fig. 44). All of these are uncoalesced to the

* Maskell: Trans of the N. Z. Institute, Vol. XXII, 1899, page 158.

† The Comstock–Needham system of terminology has been adopted by Handlirsch in all his recent papers dealing with venation of fossil insects and in his extended monograph of the fossil insects of the world. (Die Fossillen Insekten und die Phylogenie der Rezenten Formen 1906–1908). It has been with interest that the writer has noticed the application of this system of nomenclature to the group of insects with which this present paper deals, especially as the basis for his conclusion was a study of the treacheation of the wings.

base of the wing. The medial trachea is suggested merely by a very faint and delicate but constantly appearing tracing in the wing.

As in the wings of Aphididæ and Psyllidæ the radial trachea in Aleurodidæ is branched, being represented by the branches corresponding to R_1 and Rs. And as in the hind wing of all aphids and the front wing of the Chermesinæ, and the hind wing of psyllids, the *vein* radius in Aleurodes is unbranched, R_1 being lacking. The formation of the vein radius in Aleurodes is of exceeding interest. It follows the course of the radial trachea to the branching of the trachea and then proceeds along the radial sector. R_1 in the mature wing is lost and its position, if indicated at all, is suggested by the most delicate "shadowing" in the wing tissue. As has been previously stated,* the "complete absence of vein R_1" was predicted as characteristic of the Hemiptera on the basis of the two widely separated insects,—the Cicada and a Coreid, and the phylogenetic significance of the added testimony of the weakness of this vein and the trachea that precedes it, in the remote and highly specialized group of Homoptera here under consideration seems to the highest degree interesting.

The tracheation of *Aleurodicus* I have not had an opportunity to study. On the basis of figures of the mature wing (not a safe basis for this group by any means, as has been shown), however, the additional vein found there can only be interpreted as R_1. Its prominence is to be accounted for here doubtless, as in the case of its prominence in the forewing of the psyllid, by the rounded shape of the wing which results in a large wing expanse not otherwise strengthened. In response to mechanical necessity this vein, weak or absent when not needed, becomes more strongly developed.

The second vein of the wing of *Aleurodes* is cubitus as will be seen by comparing figures 44 and 45 where the second vein is shown to follow the course of the cubital trachea.

The hind wing of Aleurodes (fig. 46) has but one trachea and one vein,—the radial sector it seems inevitable to conclude.

COCCIDÆ.

Before examining wings of freshly emerged male coccids it seemed possible only to echo the sentiment of Redtenbacher,—"*Cocciden konnte ich nicht untersuchen.*"† Imagine the surprise,

* See Page 119.

† Vergleichende Studien uber das Flugelgeader der Insekten. Page 188.

then, which was caused when mount after mount of *Dactylopius* sp. on cactus showed five very delicate but perfectly distinct tracheæ. See Figure 42.

Four of these tracheæ are simple and uncoalesced to the base of the wing. They are arranged in two groups, the base of the subcostal, radial and medial tracheæ lying close together and the cubital and first anal tracheæ forming the other group at a little distance from the first.

The subcostal and radial tracheæ are both very wavy and as they lie close together, they cross and recross, often for the greater part of their length.

The medial trachea takes a median course. This consists of two interwoven branches, pursuing a common course.

The tracheæ in the wing of this coccid remain distinct until after the veins begin to form so that the relation of the two is at once discerned. One vein follows the general trail of the subcostal and radial tracheæ. This vein very evidently represents radius.

The second vein follows the base of the first tracheal group to about the point where the medial tracheal separates from the subcostal and radial. The vein here takes a direct line for the middle of the caudal margin of the wing. For slightly less than one-third the length of this vein it frequently joins the path of the cubital trachea. This corresponds most closely with media.

Besides these two main veins a short spur representing the subcosta is present.

In a wing so highly specialized as the coccid wing it is not improbable that the tracheation has lost its value as a basis for the venation. Certainly in the species studied there seems no necessary connection between the tracheæ and the veins which are found later.

In *Pseudococcus citri* the tracheation was exceedingly difficult to trace. The same veins occur in this species (fig. 41) as in the preceding (fig 43).

In many species of Coccids there are shadowed portions of the wings. It is due to this fact that we find the coccids sometimes figured with apparently four long veins, alternately dark and light, as for instance, in Westwood.*

* Westwood, J. O. Arcana Entomologica. Vol. I, Plate 6.

HISTORICAL DISCUSSION.*

As is the case with other groups of insects the names applied to the wing veins of aphids were given in the first place without homological reference to the veins of other insects. That is, we have an arbitrary system which has no significance outside the family of Aphididæ. Recently several papers have appeared which rename the wing veins with this aim in view, but as the true homologies of the wing veins themselves have not heretofore been established, certain mistakes in applying the Comstock-Needham nomenclature have, of necessity, arisen. These papers will be discussed in turn. First, however, it would seem of interest to review the earlier terminology.

For convenience in this discussion attention is called to Fig. 8, in which the names are used as based upon the homologies revealed in the study of the tracheation of the wings as recorded in this paper.

The following table will show the relation of the Comstock-Needham terminology to the terminology previously in use for the wing veins of aphids:

After Buckton	*Current terminology*	*Comstock-Needham*
	Fore Wing	(See fig. 8)
Costal Nervure	Costal	Costa (C.)
Cubitus or post-costal nervure	Subcostal vein	Subcosta (Sc)
		Radius$_1$ (R_1) (together with basal portions of the remaining wing veins).
Stigmatic	Stigmal vein	Radial sector (Rs)
First furcal	First branch	Media (M_1)
Second furcal	Second branch	Media (M_2)
Cubital nervure	Third discoidal or cubital	Media (M)
		Media $_{3+4}$ (M_{3+4})
Second oblique	Second discoidal	Cubitus (Cu)
First oblique	First discoidal	First Anal (1st A.)
	Hind Wing.	
Cubitus or post costal nervure	Subcostal vein	Radial sector (Rs).
Second oblique	Second discoidal	Media (M.)
First oblique	First discoidal	Cubitus (Cu.)

* For careful general historical discussion of studies of wing-venation see MacGillivrary, A. D. ('06). Wings of the Tenthredinoidea. PP. 570–574.

The interpretation of the so-called subcostal has been* that it is a single heavy vein spreading at the distal portion into the stigma. That this interpretation is incorrect the foregoing discussion on the tracheation has made clear. It is really a composite structure bordered along the cephalic margin by the subcostal vein and containing the radius and the coalesced proximal portions of the remaining wing veins.

It will be seen by reference to the accompanying table that the first, second and third discoidals are respectively the 1st Anal, Cubitus and Media. The second anal not persisting in the adult wing (that is, it is represented only by a constantly appearing trachea which soon clears) is not shown in any published figures of aphid wings.

In the hind wings the first and second discoidals are respectively (fig. 8) the cubitus and media, and the so-called subcostal vein is the radial sector.

Redtenbacher† gives homologies of the wing veins of aphids and psyllids, which except for his interpretation of alternate convex and concave veins, come pretty close to the conclusions arrived at from the study of the tracheation. Except for Sc and vein VI in the forewing and that Sc is not accounted for in the hind wing his psyllid wings are correct. His difficulties with the aphid wings could not be settled without reference to the tracheation.

Handlirsch‡ gives the only figure of wing tracheæ for psyllids or aphids published previous to this present paper. His interpretation of the tracheæ for the wing pad of the psyllid nymph is practically the same as that given in this paper. With the freshly emerged wing of *Schizoneura langigera*, however, three mistakes occur. The line which he indicates as the subcostal trachea does not occur as a trachea but as a well defined fold of the subcostal vein. (See page 108). The unbranched trachea which he considers M is really Cu. and his Cu. is one of the anals. The question in regard to M. and Cu. however could only be settled by the testimony of the tracheation of the wing pad. (See page 113 and fig. 21).

* Oestlund, O. W. Aphididae of Minnesota, p. 4. 1887.
Comstock, J. H. Introduction to Entomology, pp. 158–159. 1888.

† Redtenbacher, Josef. Ann. k. k. Naturh. Hofmus., I. 1886.

‡ Handlirsch, Anton. Die Fossilen Insekten und die Phylogenie der Rezenten Formen. 1906–08.

Handlirsch homologizes the veins of the Phytophthires which he figures and also names what tracheæ he figures.

In Woodworth's discussion of the wing veins of Phytophthires* the veins of these insects are homologized to the extent that the statement is made that the front wing of Aleurodidæ is the same in its maximum condition of venation as the maximum of the hind wings of Aphidæ, and the hind wings the same as the minimum of Aphidæ, and that the venation of the front wing of Coccidæ is the same as the minimum of the front wing of Aleurodidæ. This author figures wings of all the Phytophthires he discusses but as the wing veins are not labeled and it is not apparent from the text which of the "independents" he interprets the media and the cubitus to be either with the psyllids or aphids it is not possible to homologize them from his figures. The meaning of his statement that in only the Psyllidæ is the venation extensive enough to show clearly their affinity to the higher Homoptera is not apparent, as his maximum number of veins for the aphids according to his figures exceeds the maximum for the psyllids; and the number when the minimum is taken is the same for both wings except for one extra branch for the psyllids. Exception, moreover should be taken to his diagram of the venation of the Aphididæ, for the "additional independent and the cross vein at the tip" which he states are very rarely present, are never present in fact in the normal venation of any species of aphid. And if abnormal or freak veins are to be included in the venation of aphid wings there would be no reason to stop at these two, for cubitus might be branched, any of the branches of media have an extra fork and "cross-veins" might be almost indiscriminately located as between cubitus and the first anal.

In a very convenient classification of some of the external characters of Aphididæ Mr. Vickery† attempts a homology of the wing veins of aphids with those of other insects, stating that the names he gives, based upon Comstock's system, were decided upon from a study of other reduced wings such as Psocus, and from a study of the abnormal venations found so frequently in plant-lice. Mr. Vickery's homologies are based upon the comparison of mature wings and the misinterpretations which have

* Woodworth, C. W. ('06). The Wing Veins of Insects. pp. 124–125.

† Vickery, R. A. ('08). A Comparative Study of the External Anatomy of Plant-lice.

arisen are readily explained by this fact. Perhaps in no other family could be found a clearer demonstration of the value of the study of the tracheation in this connection.

SUMMARY.

The introductory discussion outlines the reasons for undertaking this study of wing vein homologies, states the conditions under which the study has taken place, and mentions some of the difficulties involved in the manipulation of this sort of material.

Attention is called to the coalescence of tracheæ both the normal occurrence and some unusual instances.

All the veins present in the four families discussed are homologized, each being taken up for detailed consideration and the tracheal basis for the homologies being carefully stated.

The historical discussion includes a notice of all such published work as has any direct bearing upon this present paper.

All the main features of venation or tracheation discussed are illustrated by the accompanying figures.

BIBLIOGRAPHY.

Buckton, G. B. Monograph of British Aphides.
Comstock, J. H. Introduction to Entomology.
Comstock, J. H. Manual.
Comstock, J. H. and Needham, J. G. Wings of Insects.
Froggatt, W. W. Australian Insects.
Handlirsch, A. Die Fossilen Insekten und die Phylogenie der Rezenten Formen 1906–1908.
Kuwayama, I von S. Die Psylliden Japans. Trans. of Sappro Natural Hist. Society. 1907–08.
Loew, F. Gen. Aphalara et Rhenocola. 1882. (Zoologisch Botanische Wien Taf. XI.)
Loew, F. Mittheilungen über Psylloden. Verh. z.–b. Wien XXIX, pp. 549–598. pl. XV. 1879.
Loew, F. Psylloden. Taf. IX. (1878.) Verh. z.–b. Wien XXVIII.
Loew, F. Revision der palaarktischen Psylloden in Hinsicht auf Systematik und Synonymie. Verh. z.–b. Wien XXXII, pp. 225–254. 1882.
Loew, F. Zur Biologie und Charakteristik der Psylloden nebst Beschreibung zweier neuer Species der Gattung Psylla. Verh. z.–b. Wien, XXVI, pp. 187–216. pls. 1 and 2, 1876.
Loew, F. Zur Systematik der Psylloden. Verh. z.–b. Wien, XXVIII, pp. 586–610, pl. IX. (Figures of the neuration of 11 genera) 1878.
MacGillivray, A. D. A Study of the Wings of the Tenthredinoidea. Proceedings of the Nat. Museum. Vol. XXIX. 1906.
Oestlund, O. W. Aphididæ of Minnesota. 1887.
Packard, A. S. 5th Report Ent. Commission.
Redtenbacher, J. Flugelgeader der Insecten. Ann. k. k. Naturh. Hofmus. I. 1886.
Riley, C. V. Notes on N. A. Psyllidæ. Biological Society of Washington, 1883.
Sanborn, C. E. Kansas Aphididæ.
Schwarz, E. A. Entomological Soc. of Washington. 1902–04. Notes on North American Psyllidæ.
Scott, J. Monograph of the British species belonging to the Hemiptera–Homoptera, family Psyllidæ; Tr. E. Soc. 1876. pp. 525–569, pls. VIII and IX.

Scott, J. On certain Genera and Species of the Group of Psyllidæ in the collection of the British Museum. 1882. Trans. Ent. Soc. London. 1882. pp. 449–473. Plates XVIII, XIX.
Scudder, S. H. Fossil Insects.
Vickery, R. A. A Comparative Study of the External Anatomy of Plant Lice. 1908.
Woodworth, C. W. The Wing Veins of Insects. 1906.

EXPLANATION OF PLATES.

The figures submitted have been selected from numerous ones prepared in the progress of this study. In their preparation two methods were employed. The figures showing tracheation are from camera lucida sketches verified or corrected by examination of each significant point through a high power lens,—oil emersion when necessary. The figures giving venation (except Fig. 29) are ink tracings of photographs,—the blue prints which were used being bleached after the drawings were made in order that black and white figures uniform with the camera lucida sketches might be secured.

PLATE XVI.

FIG. 1. *Lachnus strobi* (Fitch). Tracheation of wing of newly emerged aphid. See page 111.
FIG. 2. *Melanoxanthus* sp. Wing of newly emerged individual showing an unusual case of coalescence of tracheæ, See page 107.
FIG. 3. *Myzus cerasi* (Fab.) Tracheation of wing of newly emerged aphid. See page 110.
FIG. 4. *Aphis* species. Tracheation of wing of newly emerged aphid showing connection with the body trachea. The region of the costal vein and also the main vein channel of the wing indicated here. See page 108.
FIG. 5. *Callipterus ulmifolii* Monell. Tracheation of wing of newly emerged aphid.
FIG. 6. *Chaitophorus nigræ* Oestlund. Tracheation of wing of newly emerged aphid. See page 116.
FIG. 7. *Chaitophorus populicola* Thos. Tracheation of hind wing of newly emerged aphid. Typical, showing connection with body trachea. See page 116.
FIG. 8. *Macrosiphum solanifolii* Ashmead. Venation of both wings.
FIG. 9. *Macrosiphum pisi*. Tracheation of hind wing of newly emerged aphid. Very exceptional. See page 116.

PLATE XVII.

FIG. 10. *Microparsus variabilis* Patch. Venation of both wings. Venation of this species very unstable. The type figured is a common one.
FIG. 11. *Toxoptera graminum* Rond. Venation of both wings.
FIG. 12 and 13. *Pemphigus acerifolii* Riley. Tracheation of fore and hind wings of newly emerged aphid. See pages 109 and 117.
FIG. 14. *Pemphigus venafuscus* Patch. Venation of both wings.
FIG. 15. *Hamamelistes spinosus* Shimer. Tracheation of wing of newly emerged aphid. See page 114.
FIG. 16. *Hamamelistes spinosus* Shimer. Venation of both wings.
FIG. 17. *Tetraneura* sp. Venation of both wings.

PLATE XVIII.

FIG. 18. *Mindarus* (*abietinus* Koch ?). Tracheation of wing pad of nymph. See page 115.
FIG. 19. *Mindarus* (*abietinus* Koch ?). Tracheation of freshly emerged wing.
FIG. 20. *Mindarus* (*abietinus* Koch ?). Venation of both wings. See page 114.
FIG. 21. *Schizoneura rileyi* Thomas. Tracheation of wing pad of nymph. See page 114.
FIG. 22. *Schizoneura rileyi* Thomas. Tracheation of freshly emerged wing. See page 114.
FIG. 23. *Schizoneura americana* Riley. Venation of both wings.

PLATE XIX.

FIG. 24. *Chermes abietis* (Linn.). Tracheation. Note how the branches of the radial trachea weave along the margin. See page 110.

FIG. 25. *Chermes abietis* (Linn.). Tracheation. An extraordinary case in which the first anal trachea is distinct to the base of the wing. See page 107.

FIG. 26. *Chermes pinifoliæ* Fitch. Tracheation. An unusual case of coalescence. See page 107.

FIG. 27. *Chermes pinifoliæ* Fitch. Tracheation. An unusual case of coalescence. See page 107.

FIG. 28 and FIG. 29. *Chermes pinifoliæ* Fitch. Two camera lucida drawings of the same identical wing. Fig. 28 shows the tracheation of the freshly emerged wing, and Fig. 29 shows the course of the veins Rs, M, Cu and 1st A, twenty-four hours after Fig. 28 was drawn and after the tracheæ had all become invisible. See page 111.

FIG. 30. *Chermes pinifoliæ* Fitch. Normal tracheation of hind wing. See page 116.

FIG. 31. *Chermes*. Venation of both wings.

PLATE XX.

FIG. 32. *Phylloxera* sp. Venation of both wings.

FIG. 33. *Psylla floccosa* Patch. Tracheation of wing pad of nymph.

FIG. 34 and FIG. 35. *Psylla floccosa* Patch. Tracheation of freshly emerged fore and hind wings.

FIG. 36. *Psylla floccosa* Patch. Venation of fore wing.

FIG. 37. *Trioza* species. Venation of both wings.

PLATE XXI.

FIG. 38. *Euphalerus nidifex* Schwarz. Venation of fore wing. See page 119.

FIG. 39. *Pachypsylla celtidis* Riley. Venation of both wings. See page 119.

FIG. 40. *Anomoneura mori* Schwarz. Venation of forewing. See page 120.

FIG. 41. *Pseudococcus citri*. Venation. See page 123.

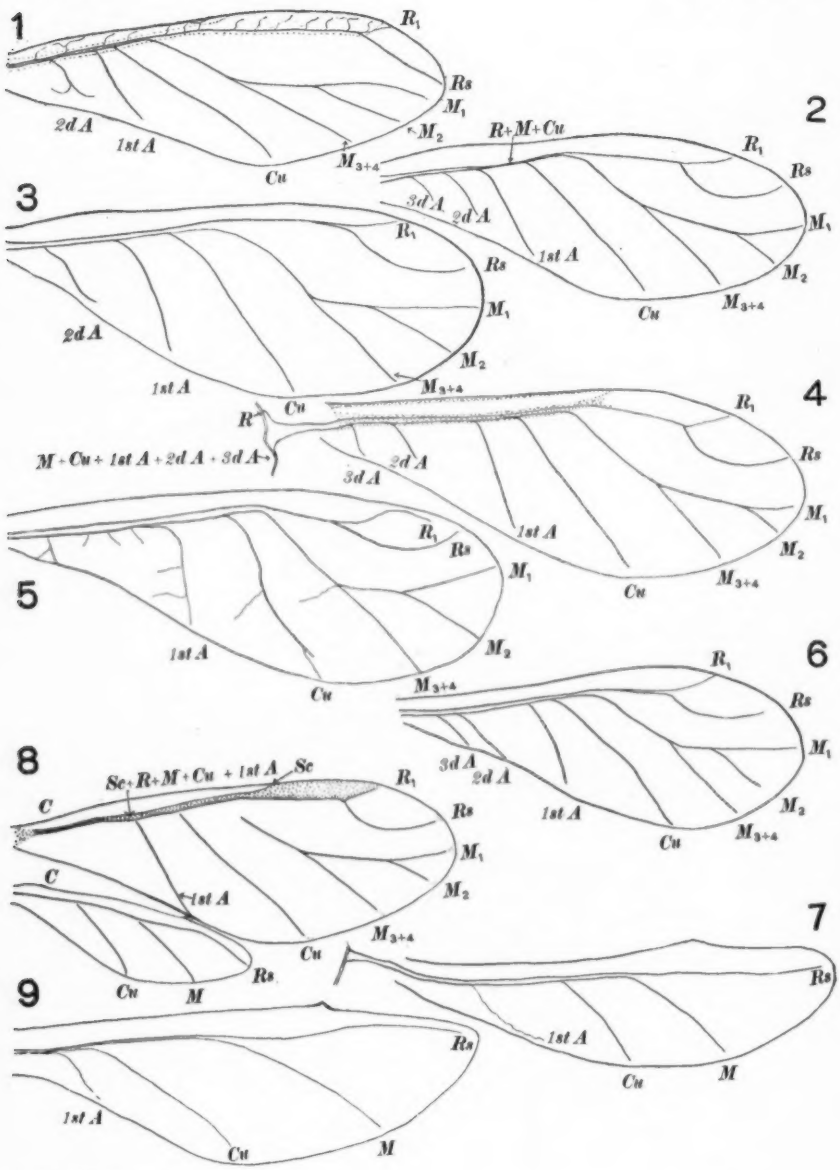
FIG. 42. *Dactylopius* species. Tracheation of freshly emerged wing. See page 123.

FIG. 43. *Dactylopius* species. Venation. See page 123.

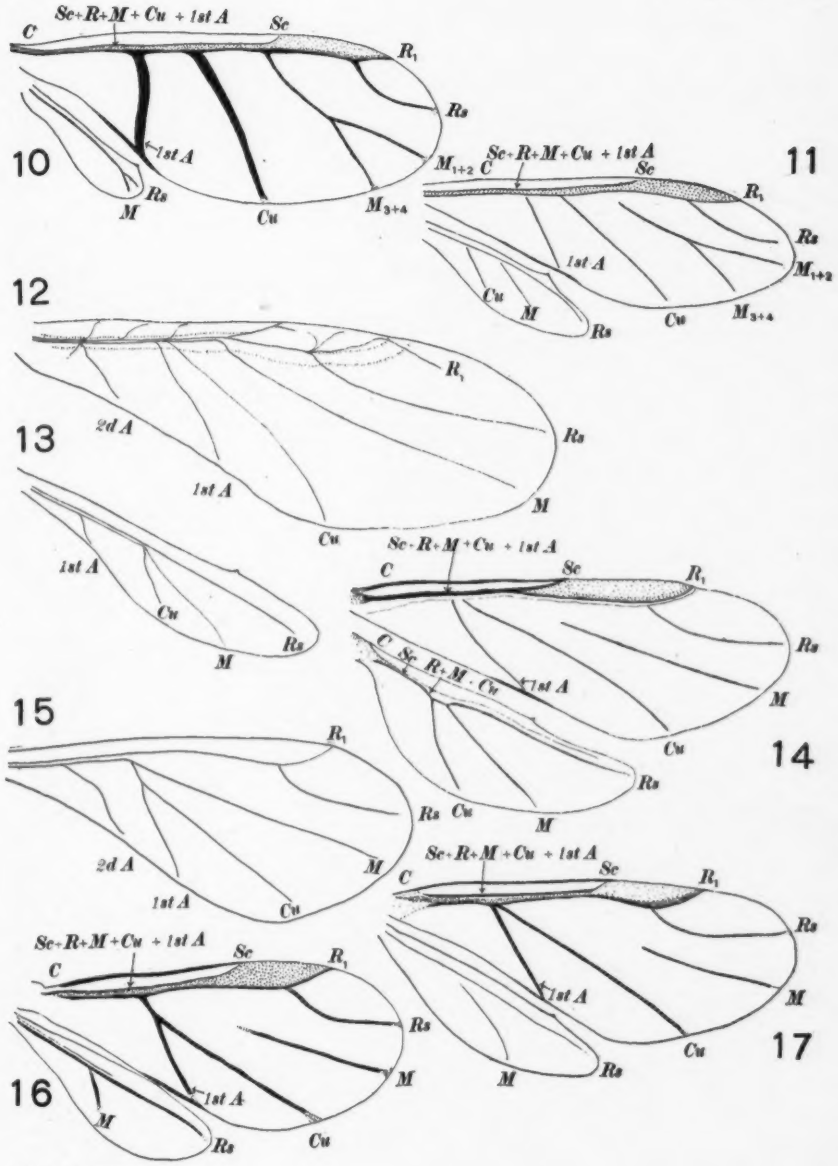
FIG. 44. *Aleurodes* sp. Tracheation of freshly emerged fore wing. See page 122.

FIG. 45. *Aleurodes* sp. Venation of forewing. See page 122.

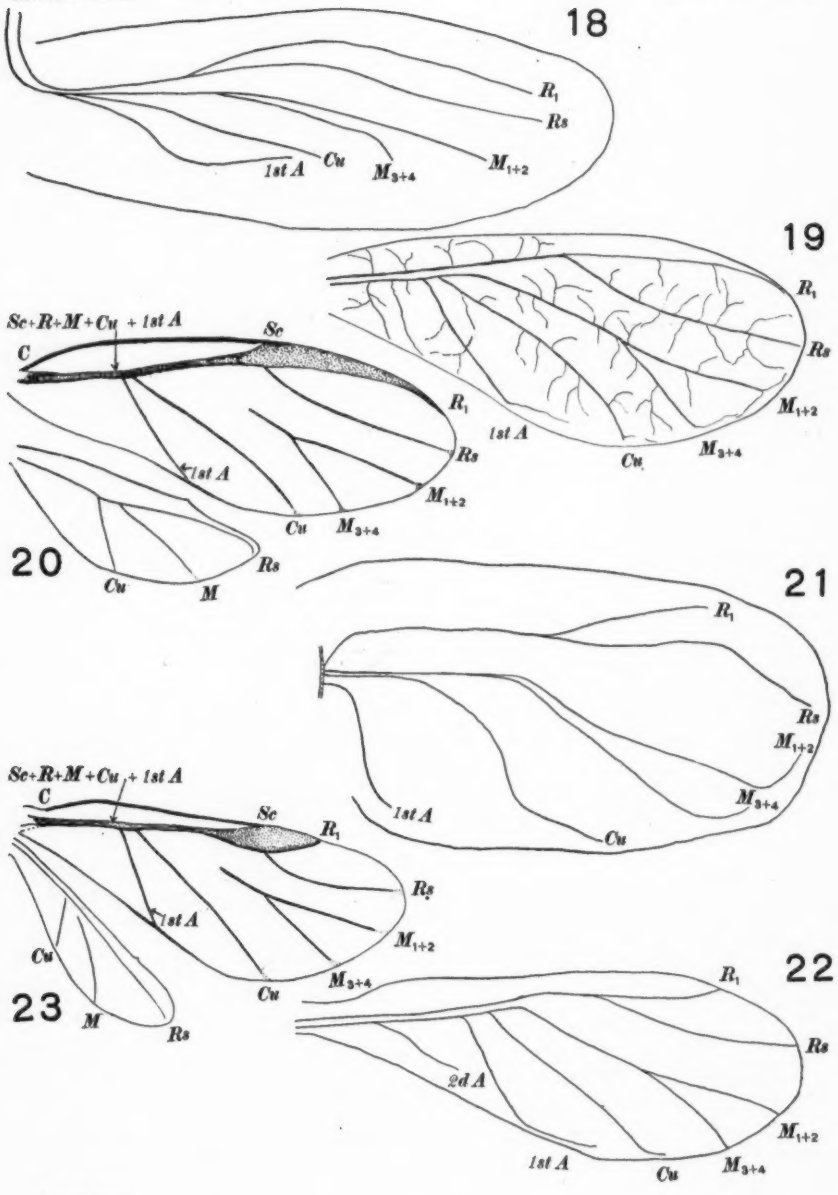
FIG. 46. *Aleurodes* sp. Tracheation of hind wing. (Venation is identical with this). See page 122.



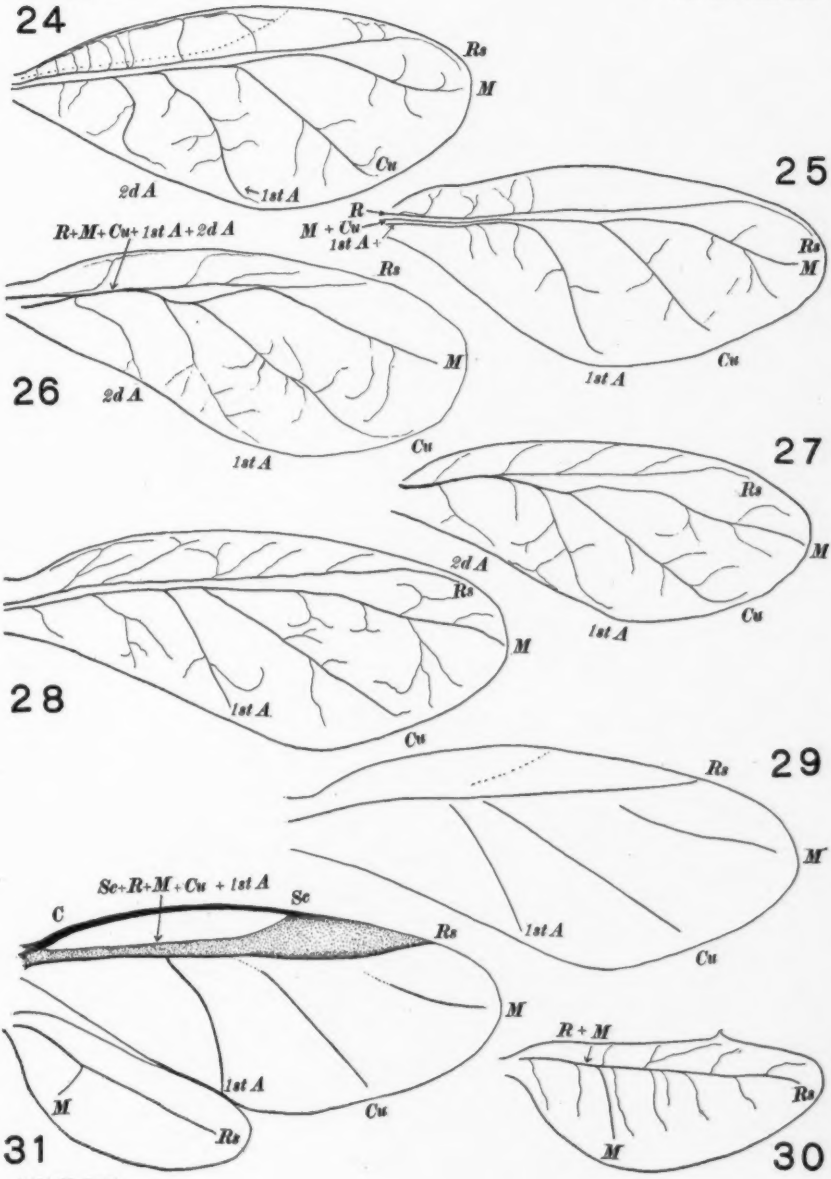
Edith M. Patch.



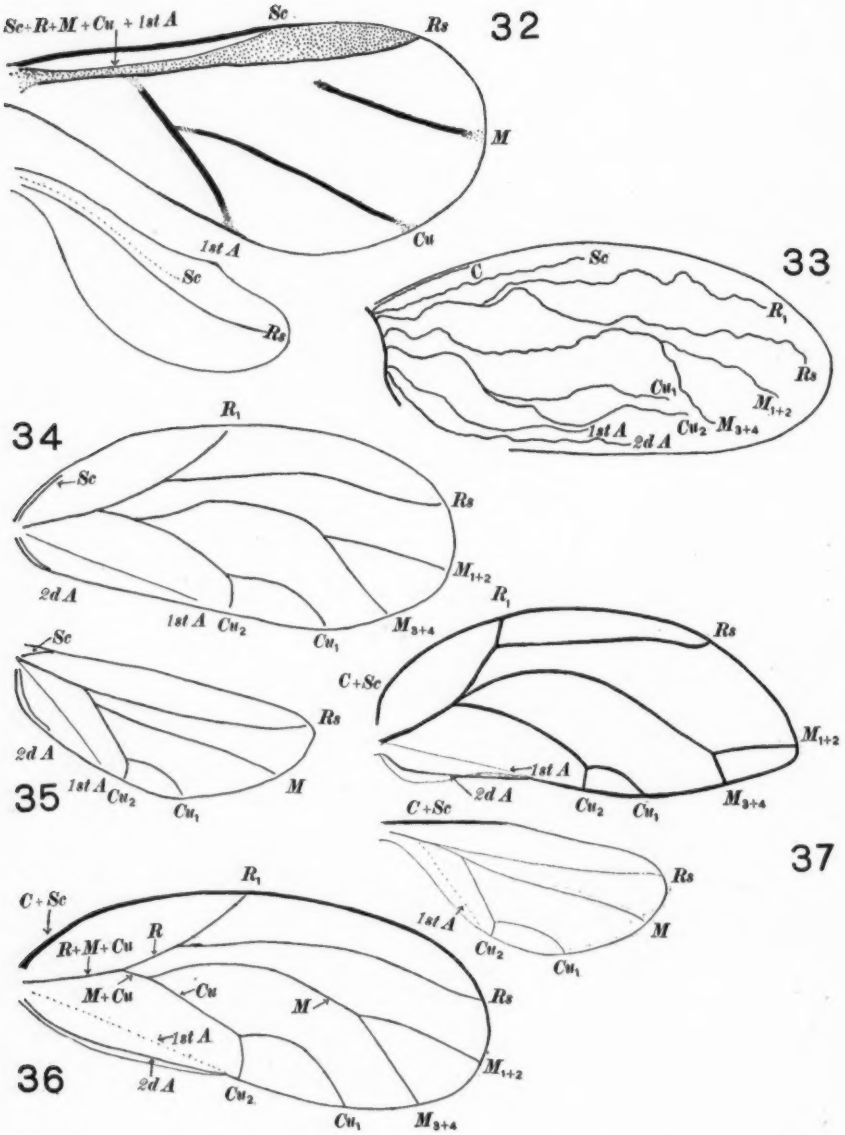
Edith M. Patch.



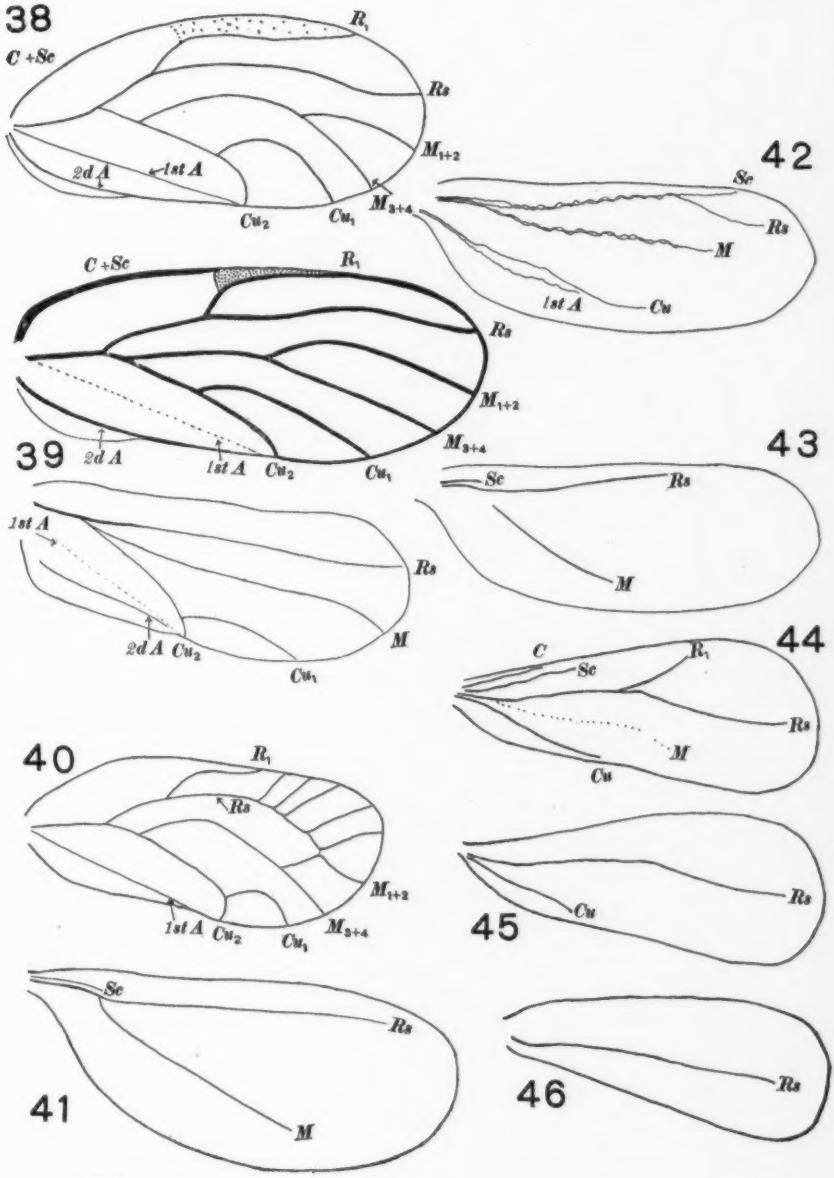
Edith M. Patch.


24
Rs
M
Cu
2d A
1st A
25
R
M + Cu
1st A
Rs
M
1st A
Cu
R+M+Cu+1st A+2d A
Rs
M
26
2d A
1st A
Cu
27
Rs
M
2d A
1st A
Cu
28
2d A
Rs
M
1st A
Cu
29
Rs
M
1st A
Cu
Sc+R+M+Cu + 1st A
C
Sc
Rs
M
1st A
Cu
M
Rs
31
R + M
Rs
M
30

Edi h M. Patch.



Edith M. Patch.



Edith M. Patch.

ROBBERFLIES OF THE GENUS ASILUS.*

JAMES S. HINE.

The insects of this genus together with a large number of others belong to the Asilidae which is a family of Diptera commonly called robberflies because of their predaceous habits in the adult stage. These habits usually lead to beneficial results but none of the species are known to show any indication that they prefer particular food. They take all kinds of insects that inhabit like places with them, and have the habit of alighting on a leaf or a stone, a log or other object, or even on the bare ground to wait for some unfortunate insect of almost any order to appear, when they leave their perch and, like a hawk, pounce upon the chosen victim and at once introduce their piercing mouthparts and suck away its life blood. Occasionally some observer finds certain species to be injurious on account of feeding on beneficial species, and it is no more than likely that all of the members of the family do some harm. Riley has stated that one of the larger robberflies may be very destructive to honey bees, and frequently one may see one or another of the flies with a parasitic insect in possession. Such habits furnish much of interest to the observer in the field, and the student who is in search of a subject full of sentiment will do well in making a selection here.

So far as known the larvae are predaceous and are found in dry ground. They work beneath the surface and seek out such available food as these situations offer. Two larvae of Asilus sericeus Say, were taken April 3, while spading a garden. They were located about six inches below the surface of the ground, color white, naked with the exception of a very few brown hairs scattered over the body, general form cylindrical, or only slightly compressed; in appearance much like what in general pass under the common name of grubs. Total length when full grown 20 millimeters. The pupa stage was reached May 25, and the adult appeared June 8.

The various species of the family are mostly large insects, but have been neglected more or less in America, some of the genera as yet not having received the attention of specialists beyond the

*Contributions from the Department of Zoology and Entomology of the Ohio State University, No. 32.

description of such species as have been brought to their attention for names. There is in the collections of the country, therefore, a quantity of undetermined material and not a few undescribed species which are a hindrance to investigators as well as to the painstaking amateurs whose ideals are to have all specimens named and grouped in reference to some particular system under a series of neatly written labels.

The genus here considered is classified in the Asilinae, one of the four subfamilies into which the family is divided in North America. In the Asilinae the species are of medium to large size, long and slender form and black, yellowish, brownish or gray color, with a close general resemblance throughout the group. The antennae each are composed of three segments of which the first is longer than the second, and the third longest of all; the latter segment at its apex bears a long style or arista composed of two segments of which the first is very short. In the wing the marginal cell is always closed, as are the fourth posterior and anal cells, and there are either two or three submarginal cells of different lengths. The members of the genus Asilus are typical of the subfamily, the antennal arista is naked, the posterior branch of the third vein reaches the margin of the wing beyond its apex, there are two submarginal cells in all cases and the veins which close the discal and first posterior cells are not parallel.

Ever since Loew monographed the European robberflies in 1848 and divided the genus Asilus of Linnæus into groups with separate names, students have been at variance as to whether or not Loew's names should be considered as genera. In Dipternfauna Sudafrica's issued in 1860, Loew himself raised his names to generic rank, but Schiner, one of the foremost students of Diptera, writing at about the same date considered Asilus in the wide sense. Later European students in the main have been inclined to follow Loew as have some Americans. Lately, however, there is a tendency to drop Loew's names and include all of the species concerned in the genus Asilus, thus following Schiner's arrangement. Thus Pandelle, an European, writing as late as 1905, and Williston of this country, in his revised edition of North American Diptera, published in 1908, have made it plain that they prefer the latter. Personal inquiry brings out the fact that nearly all of the prominent dipterologists of the United States are ready to accept Williston's views in the matter.

In his Manual Williston says that "In general the subdivisions of the old genus Asilus are very vague and hard to define, and many of them are doubtfully entitled to recognition. At the most, few, if any, of them are based upon real generic characters and the names are only useful as aids in the determination of the numerous forms."

Lundbeck, in his Diptera Danica 1908, II, 53, gives what argument there is for the other side when he says of these names that "Though it cannot be denied that as genera they are far more closely allied and taken in a narrower sense than genera are commonly, I shall yet retain them, chiefly because they are generally in use and at all events give valuable hints about the natural classification of the species."

Before beginning the study of the species considered in this paper, I procured representative specimens of Loew's groups from Europe by exchanging with Dr. M. Bezzi and others, and with these for reference have undertaken to place the North American species. The list offered below indicates the success achieved, but as may be noted some of the species do not fall naturally into any of the groups and even in some cases where a decision appears to have been reached, there are difficulties in the way of a perfectly satisfactory conclusion. It may be mentioned also that Dr. Bezzi encountered some difficulty in placing the Nearctic species, for at the end of the Asilinae in the recent Catalogue of Palearctic Diptera is a list of no less than twenty-nine species, which from the evidence cannot be placed in the so-called genera, but are given as falling under the genus Asilus in the wide sense.

By giving only Asilus generic rank and using the other names, that often have been considered as genera, simply as names of groups, some questions in priority come up for solution. Since Europeans were the first to arrange their species in reference to Loew's classification, the proper procedure would be for them to be the first to discard it. As it is students in America have described many of their species on the ground that Loew's names were valid generic terms, using the same specific name in two or more genera. If these names are considered as genera in Europe, as is the case in the recent catalogue mentioned above, and only as groups of one genus in America, a student in the latter country hardly knows what is the proper disposition of the synonymy question in his fauna. With these facts confronting me, I do

not know of a better way of accepting Williston's views on the extent of the genus Asilus than to restrict it only by the description I have given above, and this would also agree with Schiner's views so far as European species are concerned. Having reached this conclusion I have worked out the synonymy accordingly, so far as evidence could be obtained, and it develops that several of the names that have been used as names of species in America become untenable on account of having been used earlier as names of species in the Old World.

Macquart's studies in the subfamily in general preceded those of Walker, but since the former writer used a number of names that have been employed by older writers, he made some synonyms which must give way to names which Walker gave to the same species, and a similar condition exists in reference to the work of the later authors.

In his treatment of the Asilinae Lundbeck has followed Mik in reference to the method used in referring to the color and the arrangement of the bristles of the legs. When these organs are stretched out at right angles to the body, the side which looks forward is anterior. As this answers all purposes and is in use it is adopted in this paper.

I have received encouragement in this work from most of the dipterists of the United States and take this opportunity to express my appreciation of their good will. For the loan of specimens, without which I could not have hoped to attempt this paper, I am under obligations to the following museums and private parties: The United States National Museum, including an abundance of material collected by Coquillett on the Pacific Coast; the Francis Huntington Snow Collection of Kansas University; the collection of the Massachusetts Agricultural College and the collection of the University of Illinois. Chas. Dury, Chas. W. Johnson, Dr. O. A. Johannsen, Dr. C. F. Adams, Dr. W. A. Nason, Franklin Sherman, Jr., Dr. O. S. Westcott, S. A. Rohwer, H. S. Harbeck, and Dr. Nathan Banks have loaned or given me specimens from their own private collections or from the collections of the institutions which they represent. Furthermore Dr. W. D. Hunter, of the Bureau of Entomology, Washington, D. C., has sent for study a large collection of Asilinae collected during the time the studies of the cotton-boll weevil and other species have been in progress in Texas.

LIST OF THE SPECIES.

Group **Asilus.**

sericeus Say, Jour. Acad. Sci. Phil., III, 48. Compl. Works II, 63. Wiedemann, Auss. Zw. I, 429. Williston Trans. Am. Ent. Soc. XI, plate II, figure 10. Kan. Univ. Quar. II, 68. Riley Mo. Rept. II, 123. Harris Ins. Inj. Veg. 605.
herminius Walker, List II, 410.
midas Brauer, Sitzungsb. Kaiserl. Akad. Wissensch. XCI, 387, plate II, figure 1. Williston, Kan. Univ. Quart. II, 69. Osten Sacken, Biologia, Diptera I, 209.

Group **Rhadiurgus.**

leucopogon Williston, Kans. Univ. Quart., II, 75.
cacopilogus new species.

Group **Philonicus.**

arizonensis Williston, Kan. Univ. Quart. II, 76.
fuscatus new name.
obscurus Hine, Ohio Naturalist VII, 117. Name preoccupied.
limpidipennis new species.
arizonensis as determined by Hine, Ohio Naturalist VII, 116.
rufipennis Hine, Ohio Naturalist VII, 117.
truquii Bellardi, Saggio II, 52. Van der Wulp, Tijdschr. v. Ent. XXV, 116. Williston, Biologia, Diptera I, 328.
taeniatus Bellardi, Saggio II, 55. Synonymy by Williston.
plebeius Osten Sacken, Biologia, Diptera I, 209. Synonymy by Williston.
tuxpanganus Bellardi, Saggio appendix 22. Hine, Ohio Naturalist VII, 118.

Group **Nigrasilus.**

nitidifacies Hine, Canadian Ent. XL, 202.

Group **Antiphrisson.**

astutus Williston, Kans. Univ. Quart. II, 70.

Group **Eutolmus.**

lecythus Walker, List II, 451.
femoralis Macquart, Diptera Exot. Supplement II, 45.

Group **Machimus.**

avidus Van der Wulp, Tijdschr. v. Ent. XII, 82.
occidentalis new species.
tenebrosus Williston, Biologia, Diptera I, 328.
griseus Hine, Ohio Naturalist VII, 29.

Group **Neoitamus.**

affinis Williston, Kan. Univ Quart. II, 73.
coquillettii new species.
brevicomus new species.
orphne Walker, List II, 456.
auceps Van der Wulp, Tijdschr. v. Ent. XII, 84.
aeneobarbus Loew. This name was sent to Osten Sacken in a letter and so far as I can find, no description was ever written.
distinctus Williston, Kansas Univ. Quart. II, 73.
terminalis new species.
flavofemoratus new name.
flavipes Williston, Kansas Univ. Quart. II, 72. Name preoccupied.

Group **Stilpnogaster.**

auriannulatus Hine, Ohio Naturalist VII, 29.

Group **Heligmoneura.**

angustipennis new species.
latipennis new species.

Group **Cerdistus.**

willistoni new name.
angustifrons Williston, Kansas Univ. Quart. II, 71. Name preoccupied.
auricomus new species.
piceus new species.
montanus new species.
albicomus new species.
lepidus new species.

Group **Tolmerus.**

antimachus Walker, List II, 454.
callidus Williston, Kansas Univ. Quart. II, 75.
delusus Tucker, Kansas Univ. Sci. Bull. IV, 92.
johnsoni new species.
maneei new species.
notatus Wiedemann, Auss. Zw. I, 451. Williston, Kansas Univ. Quart. II, 74.
alethes Walker, List II, 454.
novæ-scotiae Macquart, Dipt. Exot. Suppl. II, 46. Williston, Kansas Univ. Quart. II, 68.
paropus Walker, List II, 455.
prospectus Tucker, Kansas Univ. Sci. Bull. IV, 94.
prairiensis Tucker, Kansas Univ. Science Bull. IV, 93.
annulipes Macquart, Dipt. Exot. I, 2, 149. Name preoccupied.
sadytes Walker, List II, 453.
tibialis Macquart, Hist. Nat. Dipt. I, 313. Name preoccupied.
snowii new name.
annulatus Williston, Kansas Univ. Quart. II, 70. Name preoccupied.

Group **Epitriptus.**

erythocnemius new species.

Group not determined.

gracilis Wiedemann, Auss. Zw. I, 445. Osten Sacken, Catal. 235, note on the type.
auratus Johnson, Proc. Acad. Nat. Sci. 1895, 305.
californicus new species.
mesae Tucker, Kansas Univ Sci. Bull. IV, 92.
rubicundus new species.

KEY TO THE SPECIES.

1. On each side of the abdomen near the incisures with a transverse row of bristles which are clearly larger than the hairs to be seen on the other parts of the segments..... 7.
   Sides of the abdomen near the incisures without bristles which are clearly larger than the hairs of the other parts of the segments.... 2.
2. Large, bright colored species, wings distinctly colored all over..... 3.
   Smaller, modest colored species, wings pale colored or hyaline..... 4.
3. Body and legs uniformly black, wings uniformly rich yellowish brown.....**midas** Br.
   Body brown, legs pale brown, wings brown with the veins margined with paler ..... **sericeus** Say.
4. Scutellum with more than a dozen long bristles on its margin, female genitalia with a circlet of strong spines at the tip..... 5.
   Scutellum with not more than half a dozen long bristles, female genitalia not with a circlet of spines at the tip..... 6.
5. Upper forceps of the male genitalia protruding half their length beyond the lower forceps.....**leucopogon** Will.
   Upper forceps of the male genitalia about equal in length to the lower .....**cacopilogus** n. sp.
6. Body black, space between the antennae and the facial gibbosity largely shining black.....**nitidifacies** Hine
   Body brown, face entirely clothed with yellowish dust.....**astutus** Will.

7. Ovipositor short, conical, with four spines on the upper side at the apex, upper forceps of the male genitalia excavated on the apical part so that when viewed from above there is a distinct open space between them ..... 8.
   No spines at the tip of the ovipositor ..... 13.
8. Legs in large part reddish ..... 9.
   At least the femora of all the legs black ..... 12.
9. Largest species falling under 7, wings smoky, legs dark red, abdomen pure black banded with gray ..... **arizonensis** Will.
   Smaller species, wings hyaline or reddish, abdomen gray black banded with gray ..... 10.
10. Wings limpid, legs pale reddish, brown of fuscus in places ..... **limpidipennis** n. sp.
    Wings reddish, legs pale reddish, usually black in places ..... 11.
11. Legs rather slender, anterior side of each femur in large part black, upper forceps of the male genitalia with the angle at the beginning of the excavation produced inward and backward so that it meets and crosses its fellow of the opposite side ..... **truquii** Bell
    Legs rather thick, each femur black except at the tip of the anterior side, angle of the upper forceps not produced ..... **rufipennis** Hine
12. Legs, except the extreme bases of the tibiae, black ..... **tuxpanganus** Bell.
    Tibiae and tarsi in large part reddish ..... **fuscatus** n. name.
13. Arista of the antenna about twice as long as the third antennal segment, legs almost entirely pale reddish ..... **gracilis** Wied.
    Arista at most only a little longer than the third antennal segment, legs usually partly black ..... 14.
14. Four or more bristles on the margin of the scutellum, ground color of the abdomen, except in one species, clear black ..... 15.
    Normally two bristles on the margin of the scutellum. These bristles may be variable to the extent of having one or two additional smaller ones in an occasional specimen of a species ..... 23.
15. Wings glassy hayline, legs in part bright yellow, Sixth and seventh segments of the female abdomen shining black, that is, included in the ovipositor ..... 18.
    Wings partly brownish, legs in part pale reddish. Sixth and seventh segments of the female abdomen not included in the ovipositor .. 16.
16. Dark gray species with gray posterior margins to the abdominal segments. Posterior margin of the eighth ventral abdominal segment produced and furnished with a dense tuft of coarse hairs ..... **occidentalis** n. sp.
    Black species. Posterior margin of the eighth ventral abdominal segment not produced and not furnished with a tuft of hairs .... 17.
17. Shining black species with golden posterior margins to the abdominal segments ..... **auriannulatus** Hine
    Rather dull black species with gray posterior margins to the abdominal segments ..... **callidus** Will.
18. Hairs of the face, mystax, bright yellow. Male forceps notched on the upper side at the apex ..... 19.
    Mystax wholly or in part black or white, or else the male forceps not notched on the upper side at the apex ..... 20.
19. All the femora black ..... **orphne** Walker
    Front and middle femora almost entirely yellow ..... **affinis** Will.
20. Front and middle femora yellow, each with a black stripe on the upper side ..... **flavofemoratus** n. name
    All the femora black, at most with only a preapical band yellow .... 21.
21. Male forceps notched on the upper side at the apex ..... 22.
    Male forceps not notched on the upper side at the apex .... **terminalis** n. sp.

22. Dorsum of the thorax for its entire length with a crest of long hairs ..... **coquillettii** n. sp.

    Dorsum of the thorax with the hairs on the anterior part distinctly shorter than on the posterior part..... **brevicomus** n. sp.

23. From dorsal view male forceps wider at two thirds their length than at their base. First segment of the female ovipositor, that is, the eighth abdominal segment longer than the sixth and seventh united..... 24.

    From dorsal view male forceps gradually narrowed from near the base to the apex. First segment of the female ovipositor of normal length, not so long as the sixth and seventh segments united..31.

24. Male forceps distinctly wider than the abdomen at the middle of its length..... 25.

    Male forceps not wider than the abdomen at the middle of its length..26.

25. Wings narrow, male genitalia more than two millimeters in width at the apex..... **angustipennis** n. sp.

    Wings wide, male genitalia less than two millimeters in width at the apex..... **latipennis** n. sp.

26. Mystax golden, usually with a few black bristles above. Preapical bristles of the abdominal segments pale yellow, male wings not distinctly brown at middle..... **auricomus** n. sp.

    Mystax gray with some bristles above, or if the mystax is not gray, the wings of the male are distinctly brown at middle, preapical bristles of the abdominal segments gray..... 27.

27. Wing of the male distinctly brown at the middle of the length..... 28.

    Wing in both sexes hyaline, or very faintly tinged with reddish all over 29.

28. General color black. Viewed from above the male genitalia on each side evenly curved to the apex..... **lepidus** n. sp.

    General color brown. Viewed from above the male genitalia on each side quite suddenly contracted just before the apex..... **willistoni** n. name.

29. Facial gibbosity small, not reaching half way to the antennae, wings hyaline ..... **montanus** n. sp.

    Facial gibbosity large, reaching more than half way to the antennae..30.

30. Body gray, legs red, wings faintly tinged with reddish, bristles and hairs of the body white..... **albicomus** n. sp.

    Body black, legs dark, wings very faintly smoky, bristles of the thorax and legs mostly black..... **piceus** n. sp.

31. Wings clear hyaline, rather large species, upper forceps of the male genitalia split at the tip..... **californicus** n. sp.

    Wings washed or spotted with gray at the apex and along the posterior border, species of variable sizes, upper forceps of the male genitalia entire at the apex..... 32.

32. Very small species; antennal arista very short, not over one fourth the length of the third segment and not distinctly differentiated from this segment..... **mesae** Tucker.

    Larger species, antennal arista distinctly differentiated from its segment..... 33.

33. Arista of the antenna about as long as the third segment, only two bristles in addition to the apical bristles on the front side of the hind tibia. These bristles are not entirely uniform but may be depended upon usually..... 34.

    Arista of the antenna usually not over two thirds as long as the third segment, three bristles on the front side of the hind tibia....44.

34. Gray of the wings in the form of spots in the cells at the apex and along the posterior border, leaving the veins margined with hyaline ..... **tenebrosus** Will.

Apex and posterior border of the wing uniformly gray. In some species this coloring is very feint ..... 35.

35. Ventrally the posterior margin of the eighth abdominal segment of the male is somewhat produced ..... **avidus** v. d. Wulp.

Ventrally the posterior margin of the eighth abdominal segment is not produced ..... 36.

36. Black species ..... 37.
Gray, brown or yellowish brown species ..... 40.

37. Small species, legs black, at most with just a trace of reddish on the base of each tibia ..... **maneei** n. sp.
Larger species. Legs plainly marked with red ..... 38.

38. Male upper forceps long, usually longer than the last three abdominal segments together. Mystax largely black ..... **sadytes** Walker

Male upper forceps shorter, usually about as long as the first two abdominal segments together. Mystax largely light ..... 39.

39. Eastern species. Each tibia red on basal third ..... **notatus** Wied.

Western species. Each tibia largely red, especially on the posterior side ..... **callidus** Will.

40. Rather large species, wings wide, end lamellae of the ovipositor wedged in ..... **lecythus** Walker

End lamellae of the ovipositor not wedged in ..... 41.

41. All the femora wholly black ..... **novae-scotiae** Macquart
Femora partly red, at least each with a preapical red band ..... 42.

42. Femora variable, sometimes wholly red, commonly with only the posterior side red, mystax almost always white or yellowish white. 43.

Femora largely black, mystax in large part black, from side view male genitalia widest at two thirds the length ..... **erythocnemius** n. sp.

43. Small reddish species, mystax straw yellow, legs mostly red, male genitalia red ..... **rubidus** n. sp.

Larger species, mystax white, occasionally a few black bristles above, male genitalia black ..... **antimachus** Walker.

44. Small reddish species, legs red, at most only the anterior side of each femur slightly darkened, male genitalia red ..... **rubicundus** n. sp.
Femora in large part black. Species of ordinary size ..... 45.

45. Each femur with a preapical band and the posterior side red ..... 46.
Each femur with only a preapical band red ..... 48.

46. Dull gray species, under side of each front femur with numerous gray hairs ..... **delusus** Tucker

Bright gray or yellowish species, under side of each front femur with a longitudinal row of bristles ..... 47.

47. Thorax with a very distinct mid-dorsal black stripe which reaches its entire length, male genitalia dark red ..... **johnsoni** n. sp.

Mid-dorsal thoracic stripe not very distinct and abbreviated behind. Male genitalia black, or at least dark fuscus ..... **prairiensis Tucker.**

48. Under side of each front femur furnished with abundance of rather long hairs, not in rows ..... **snowii** n. name.
Under side of each front femur with a row of bristles ..... 49.

49. Bristles on the under side of each front femur white and rather weak. Upper forceps of male genitalia from side view widest at two thirds the length ..... **erythocnemius** n. sp.

Bristles on the under side of each front femur rather stout, nearly always partly or wholly black, upper forceps of the male genitalia from side view of the same width throughout ..... **paropus** Walker

Asilus gracilis Wiedemann. (Figs. 1 and 2.)

A long slender species with yellow body and legs, facial gibbosity very small, mystax composed of a few white bristles. Length 15–17 millimeters.

Head rather large, face and front narrower than usual; palpi and proboscis dark, the former clothed with light hair; first two segments of the antenna yellow, third brown, first segment longer than the second, arista near twice as long as its segment; occipito-orbital bristles largely yellow, although in some specimens these are nearly all black. Facial gibbosity hardly evident, mystax composed of a dozen or so light colored hairs and bristles. Thorax yellow, thinly clothed with gray dust, mid-dorsal stripe dark brown; wings hyaline with a slight clouding at the apex and along the posterior border; legs pale, anterior side of each femur, apex of each tibia and of each tarsal segment usually darker, although there is quite an amount of variation in the color of the legs. Abdomen somewhat darker than the rest of the body, nearly uniformly colored but with narrow band on the posterior border of each segment a little lighter; these narrow bands are each preceded by about four yellow bristles on either side of the abdomen. Male upper forceps short, rounded at the tip, of nearly the same width throughout; lower forceps dropped so that there is always a distinct space between the upper and lower; end lamella of the oviduct style-like.

Specimens from North Carolina, Texas, Florida, and Georgia. The type of Asilus auratus has been studied and is this species without question. The long antennal arista makes the species easy of identification.

Asilus lecythus Walker (Figs. 3 and 4).

Asilus femoralis Macquart is this same species but as there is an older Asilus femoralis by Zeller from Europe, Isis 1840, 49, 3, Walker's name must be used.

Color yellowish brown; femora largely black but each with preapical band and often with the posterior side yellow, tibiae and tarsi in large part yellow. Length 18–21 millimeters.

Face and front covered with pale yellowish dust; facial gibbosity prominent, mystax composed of a few black hairs above and numerous pale yellowish hairs below, beard pale, palpi and proboscis black, the former with light colored hairs; antennae largely black but apex of second and base of third joints plainly yellow; first two segments together equal in length to the third which is of nearly the same length as its arista. Occipito-orbital bristles black and yellowish, somewhat variable; other bristles and hairs of the occiput light colored. Thorax dull gray on the sides, more yellowish above, mid-dorsal brown stripe divided anteriorly; wings largely hyaline, apical portion and posterior border slightly clouded; coxae colored like the sides of the thorax, femora variable, in some specimens black with the exception of the preapical band; in others, the whole posterior side yellow, even the different femora of the same specimen may vary in coloration; tibiae

yellow each with a narrow black apex, metatarsi yellow apex of each black; other tarsal segments black mostly with yellow bases. Abdomen dark brown in ground color, thinly clothed with yellowish dust; posterior margin of each segment plainly lighter colored than the other parts and preceded on each side by a few bristles. End lamella of the oviduct wedged in.

This is the only American species known to me with the end lamella of the oviduct wedged in. Specimens from Pennsylvania, New Jersey, Maryland, North Carolina, Massachusetts, Maine, Ohio.

Asilus tenebrosus Williston (Fig. 5).

Machimus griseus Hine, The Ohio Naturalist VII, 29, is a synonym. There is an older Asilus griseus Wiedemann from Java, Dipt. Exot. I, 192, 17.

Male and female brownish gray with reddish legs and narrow white margins at the apexes of the abdominal segments. Wings hyaline with well defined dark markings in the cells at the apex and along the posterior margin. Length 17 to 20 millimeters.

Front and face of usual width, facial gibbosity prominent extending two thirds of the distance from the oral margin to the antennae; mystax black above and white below; antennae black, rather long, third segment of each with its style decidedly longer than the other two segments combined, style about equal in length to the remainder of the segment, beard white. Thorax dark in ground color but clothed with gray dust which is denser in some places than in others, thus giving the part a variegated appearance; a wide mid-dorsal black stripe divided anteriorly by a narrow grayish interval; scutellum with two black bristles at the apex; legs red with numerous black bristles, coxae black, each femur dark on the anterior side except just before the apex; wing clear hyaline with dark markings as follows: marginal, both submarginal and first posterior cells each with a stripe which reaches the apex of its respective cell; second posterior, discal and anal cells each with an angular spot not contiguous with the margin of the wing; halteres pale yellowish. Abdomen of the same general color as the thorax, with a light colored annulation preceded by a row of white bristles at the apex of each segment. Eigth segment of the male distinctly produced below, but not with an appendage as in some of the European species of the group; male genitalia reddish in color, oviduct shining black.

Several specimens from southwestern Colorado and Huachuca Mountains, Arizona; Flagstaff and Williams, Arizona, collected by H. S. Barber; White Mountains, New Mexico, by Townshend; Pecos and Beula, New Mexico, the latter place at an elevation of 8000 feet, by Cockerell.

The hyaline wings with the dark colored markings in the cells as described and the wide male genitalia are sufficient to separate the species from its near relatives.

Asilus avidus Van der Wulp (Fig. 6).

General color reddish gray, abdomen darkest and with prominent gray margins to each of the segments above; eighth ventral segment of the male slightly produced posteriorly but with only a few bristly hairs on its margin. Preapical band and usually the posterior side of each femur and the tibiae and tarsi dark reddish. Length 15–18 millimeters.

Facial gibbosity rather prominent. With black bristles above and yellowish gray bristles below; each antenna black, third segment exclusive of the arista scarcely as long as the other two, arista hardly as long as the third segment; beard white; occipito-orbital bristles yellowish gray with the exception of three to five black bristles behind the upper part of each eye. Thorax gray with the usual dark markings above, bristles of the posterior part prominent and black, about four black bristles on the margin of the scutellum. Legs clothed with fine hair and prominent bristles; the hair is either white or yellowish but the bristles are black; each coxa and the anterior side of its femur black, otherwise each leg is reddish, slightly darker in some places than in others. Wing hyaline with a slightly darkened tinge at the apex. Abdomen rather dark but appearing yellowish gray from certain angles; narrow posterior margin of each segment plainly gray, margin of the eighth segment below in the male plainly produced and forming a distinct angle but not with so prominent a tuft of hairs as in occidentalis.

Several specimens from Copeland Park and North Boulder Creek, near Boulder, Colorado, the latter part of August and the first part of September, 1907. Collected by S. A. Rohwer and Glen M. Hite. Also from Beula, New Mexico, 8000 feet elevation, by Cockerell.

Everything considered this is most like Van der Wulp's species. The tibiae are most plainly red at base but nowhere is there a sharp differentiation of colors as in most specimens of occidentalis. The male genitalia are nearly straight, and in this respect quite different from those of occidentalis. The latter character more than any other has led to the determination of this species as avidus.

Asilus occidentalis n. sp. (Fig. 7).

General color gray with the thorax often yellowish gray. In some specimens each femur has a preapical reddish band, in others this is not the case. Posterior margin of the venter of the male eighth abdominal segment furnished with a dense cluster of rather long bristly hairs. Length 14–18 millimeters.

Facial gibbosity prominent, mystax largely black but with a number of yellowish hairs below; face clothed with yellowish dust, beard white; each antenna black with the third segment exclusive of the arista slightly longer than the first two segments together, arista scarcely as long as the third segment. Occipito-orbital bristles mostly black, but in some specimens nearly all yellow. Thorax gray or yellowish gray, median darker markings not especially prominent, scutellum with at least four bristles on its margin. Legs dark, each femur

may or may not have a preapical reddish band; each tibia plainly reddish at the base and this color is not always well defined below and may extend nearly the whole length, especially on the upper side; tarsi black although the metatarsi are often largely reddish; wings hyaline with the apex and the inner margin of each faintly gray. Abdomen dark, differing slightly according to the angle from which it is viewed, posterior margin of each segment plainly gray.

Specimens are at hand from British Columbia collected by Harvey, Venables and R. S. Sherman; Ormsby County, Nevada, by C. F. Baker; several counties in southern California by Coquillett; also from Eldorado County, California, and from Oregon and Washington.

The fact that the male genitalia are bent upward near the middle as shown in the figure, serves to designate the species. It is much like Asilus notatus of the eastern states but in the male the extension of the ventral margin of the eighth abdominal segment with its dense tuft of long hairs, is distinctive and in both sexes the form of the third antennal segment is a useful character. In occidentalis this antennal segment is plainly wider than in notatus.

Asilus auricomus n. sp. (Figs. 8 and 9).

General color yellowish gray, mystax largely composed of golden yellow bristles, also, yellow bristles before the incisures of the abdominal segments. Legs yellow with an elongate black marking on the anterior side of each femur and a black spot at the apex of each tibia. Length 15 millimeters.

Front and face rather narrow and covered with yellowish gray dust. Facial gibbosity rather prominent, reaching half way to the antennae, furnished with yellow bristles intermixed above with a few black ones. Beard gray, occipito-orbital bristles yellowish gray. Antennae black, third segment of each exclusive of the arista about equal in length to the other two; arista decidedly longer than the third segment. Thorax yellowish gray with the usual dark markings; scutellum clothed all over with rather long yellow hairs and with two yellow bristles on the margin. Wings hyaline on the basal part, and grayish at the apex and along the inner margin. Legs largely shining yellow; coxae dark, clothed with gray dust and yellow hairs; each femur with an elongate black marking on the middle of the anterior side; each tibia with a black spot at the apex of the anterior side; tarsi infuscated, especially on the apical part of each segment; pulvilli yellow. Abdomen yellowish gray with yellow hairs on the segments and several yellow bristles on each side before the incisures. Male appendages, viewed from above, widest near the apex; each appendage black on the basal part and yellowish distally.

Several specimens of both sexes from Medina County, Ohio, taken in August. Others from Iona, N. J., collected by E. Daecke, New Haven, Connecticut, by R. L. Butrick, southern Illinois by C. A. Hart, and from Germantown, Pa.

Asilus piceus n. sp. (Figs. 10 and 11).

Nearly black species with hyaline wings and brown legs. Length 15 to 17 millimeters.

Facial gibbosity not very prominent, reaching half way to the antennae, mystax composed of black and white hairs, intermixed, beard white, occipito-orbital bristles largely black, face and front clothed with gray dust, antennae black, third segment exclusive of the arista near the length of the other two, arista equal to the third segment in length. Thorax brown in ground color, clothed with gray or yellowish gray dust, mid-dorsal stripe rather wide, black, split on the anterior part and abbreviated behind; wings clear hyaline in both sexes, veins brown; legs brown with light colored hairs and with light and dark bristles. Coxae colored like the thorax, anterior sides of all the femora, apexes of all the tibiae and the last four segments of each tarsus darkened more or less. Abdomen black, posterior margins of the segments narrowly gray, male forceps distinctly excavated at the upper corner of the apex, first segment of the oviduct nearly as long as abdominal segments five, six and seven; apical segment style-like and near the length of abdominal segment seven.

Specimens from Amherst, Massachusetts, from the collection of the Massachusetts Agricultural College.

Asilus montanus n. sp. (Figs. 12 and 13).

Rather small, slender, gray species with hyaline wings, largely reddish legs, very small facial gibbosity and mystax composed of a few bristly hairs which are mostly white, although there are a few black ones above. Length 13 millimeters.

Face clothed with gray dust; palpi and proboscis black, the former with white hairs; occipito-orbital row of bristles with a few black ones back of each eye, otherwise all the bristles and hairs of the occiput white. Thorax gray, mid-dorsal stripe black, divided before and abbreviated behind; several black bristles on the posterior part, two black bristles on the margin of the scutellum. Wings clear hyaline; legs reddish, anterior side of each femur, apex of each tibia and each tarsal segment fuscous. Abdomen clothed with grayish dust, most pronounced on the posterior margins of the segments. These margins are preceded on each side by two or three small bristles. Forceps of the male shining brownish black, each upper with a distinct angle on the dorsal side at about four fifths of the length.

This species is entirely distinct from its relatives on account of its small facial gibbosity and the few bristles composing the mystax. The male genitalia are distinctive also.

A male collected by Cockerell at Alpine Tavern, Mount Lowe, California, at an altitude of 5,000 feet. Taken August 12th. Type in the United States National Museum.

Asilus albicomus n. sp. (Fig. 14).

Medium sized gray species with red legs and hyaline wings in both sexes. Bristles of the whole body, except a few on the feet and in the extreme upper part of the mystax, white. Length 13 to 15 millimeters.

Facial gibbosity prominent reaching nearly half way to the antennae. Mystax composed of many light hairs, only a few dark ones above; bristles and hairs of the occiput light colored; thorax gray with the usual dark markings above; wings hyaline in both sexes; legs red, femora a little darker anteriorly than posteriorly; each abdominal segment with a gray posterior margin preceded by a row of white bristles which reach nearly over the dorsum, especially forward.

Both sexes taken by H. K. Morrison in Montana. Type male and female in the United States National Museum.

Asilus lepidus n. sp. (Figs. 15 and 16).

Dark colored species, facial gibbosity prominent, mystax composed of numerous hairs, femora largely black, especially on the anterior sides; tibiae mostly reddish, wings in the female hyaline, in the male infuscated, especially on the posterior half. Length 15 millimeters.

Facial gibbosity prominent, mystax composed of numerous hairs, black above, light below; antennae black; thorax clothed with gray dust leaving the usual markings on the dorsum nearly bare, black bristles on the posterior part above, scutellum with two black bristles on its margin. Wing in the female clear hyaline, in the male somewhat infuscated especially beyond the branching of the second and third veins, and somewhat along the veins of the basal part of the wing. Legs with femora black anteriorly and dark reddish posteriorly, tibiae dark reddish, apex of each darkest, metatarsi largely red, other tarsal segments mostly fuscous. Abdomen black, each segment above with a prominent gray border which is preceded by a row of bristles which nearly reaches over the dorsum of the insect, especially forward.

Male from Colorado. Female from the White Mountains of New Mexico, about 6800 feet elevation, collected July 23, by Townsend. Types in the United States National Museum.

Asilus willistoni n. n. (Figs. 17, 18 and 19).

New name for Asilus augustifrons Williston, which is preoccupied by Asilus augustifrons Loew from Asia Minor, Linn. Ent. (1849) IV, 126, 64.

Rather large grayish brown species with brown legs and narrow front and face, wings of the male more or less dark from the base of the first submarginal cell, of the female nearly clear hyaline. Length 15 to 20 millimeters.

Head of medium size; front and face narrow, clothed with dust which varies in different specimens from gray to golden, facial gibbosity prominent, mystax composed of a large number of hairs, which are black above and white, or sometimes golden, below. Antennae black, first two segments nearly equal in length and together about as long as the third which is of nearly the same length as the arista.

Beard gray; occipito-orbital bristles gray as are all the hairs of the occiput. Palpi and proboscis black, the former with gray hairs. Thorax gray, often with a yellowish tinge above, mid-dorsal stripe black. Wings yellowish in the male quite dark from the base of the first submarginal cell, especially along the costal border; in the female the wings are much lighter than in the male and in some specimens these are practically hyaline. Legs brown, femora somewhat variable but usually distinctly darker anteriorly, tibiae darkened at the apexes, tarsal segments mostly dark, but the first on each leg lighter except at the apex. Abdomen brownish black; on the posterior margin of each segment is a white band which is preceded by a row of white bristles which are largest anteriorly. Male forceps black and shining, upper forceps swollen, thickest beyond the middle of their length, oviduct long and slender but not including the seventh abdominal segment.

The description and drawings were taken from the type specimens which are in the Francis Huntington Snow collection of the University of Kansas. Other specimens from western Washington collected by H. K. Morrison, Vernon, B. C., by E. P. Venables, Goldstream, B. C., by R. V. Harvey.

Asilus auriannulatus Hine.

General color shining blue-black with uniform pale brown wings and black and yellow legs. The second, third and fourth segments of the abdomen each with a golden yellow annulus at the apex. Length 14 to 17 millimeters.

Front and face rather narrow, the latter covered with golden yellow pollen between the callosity and the antennae, callosity slightly elevated, mystax black, beard white, third segment of the antenna about as long as the other two together, style shorter than the remainder of the segment; thorax dark in ground color, clothed with pollen which is denser in some places than in others, mid-dorsal stripe opaque black, narrowly divided on the anterior part; scutellum with several black bristles at its apex; wing uniformly pale brown all over with a slight intensity of coloration on the margin of the second vein near the middle of its length. Legs black and yellow, a preapical ring on each femur, all the tibiae except at apexes and bases of the tarsal segments yellow, other parts black; hind femora somewhat variable in that the yellow is likely to increase at the expense of the black; halteres yellow. Abdomen shining blue-black, second, third and fourth segments each with a golden yellow annulus at apex not preceded by a row of bristles; eighth segment below not widened but furnished with a conspicuous tuft of erect hair. Genitalia of both sexes shining black, of the male somewhat wider than the abdomen when viewed from above and about as long as the seventh and eighth segments combined.

Several specimens of both sexes taken in the Hope Mountains of British Columbia by R. V. Harvey and R. S. Sherman of Vancouver, during the first part of July. Also from Kalso, B. C., collected by R. P. Currie, western Washington, by H. K. Morrison, Humboldt County, California, by H. S. Barber, and from several other places in California and Washington.

Asilus angustipennis n. sp. (Figs. 22 and 23).

Dark species, ground color somewhat obscured by a thin covering of yellowish dust, wing rather wide, whitish hyaline on the basal part, brownish beyond the branching of the second and third veins, especially near the costal border. Length 16–18 mm.

Head rather large, front and face narrow and clothed with golden dust, facial gibbosity rather prominent but not reaching more than half way to the antennae, mystax composed of numerous bristles which are black above and yellow below, beard not abundant, fine and yellowish white in color; palpi, antennae and proboscis black; posterior orbits clothed with pale bristles and hairs. Thorax clothed with yellow dust and black bristles and hairs, the usual black mid-dorsal stripe divided before, and some blackish spots on either side; scutellum with two yellow bristles on its margin and numerous short light colored hairs on its disk. Wings hyaline at the base but quite distinctly darkened on the outer half, this darkening is most pronounced along the costal margin before the small cross vein. Legs black and reddish; base apex and posterior side of each femur, most of each tibia and bases of the tarsal segments reddish; coxa, trochanter, most of the anterior side of each femur, apexes of tibiae and tarsal segments black; many of the bristles of the legs are light, although there are some black ones. Abdomen clear brown, each segment with a narrow apical band of pale yellowish preceded on either side by some light colored bristles. Male genitalia thickened and much wider than the rest of the abdomen..

A male taken by R. S. Woglum, at Highlands, North Carolina, in September, 1906, and sent in by Franklin Sherman, Jr. Also a male from St. Elmo, Virginia, taken by F. C. Pratt, September 13th. The latter specimen is in the U. S. National Museum.

Asilus latipennis n. sp. (Figs. 24 and 25).

Rather dark in color, hairs and bristles of the body mostly yellow. Length 15–17 millimeters.

Facial gibbosity rather small, mystax yellowish below, black above, beard yellowish gray, face above the gibbosity rather narrow and clothed with golden dust; antennae, palpi and proboscis black, third antennal segment about as long as the other two, arista about the length of its segment, bristles and hairs of the occiput mostly pale yellow. Thorax clothed with yellowish gray dust, with a wide mid-dorsal stripe and two spots on either side dark brown. Legs black and yellow with black bristles and yellow hairs, femora largely black in some specimens, more or less yellowish in others, in all cases observed the hind femora are yellow at the base; all the tibiae are yellow with narrow black apexes, base of each first tarsal segment yellowish, otherwise the tarsi are brown. Wing in the male wide, whitish hyaline on the basal third, lightly clouded with brownish from thence to the apex, region of the stigma plainly brown. Wing of the female hyaline, only obscurely clouded at the apex. Abdomen thinly clothed with brown dust, posterior margin of each segment yellow,

and preceded on either side by several yellow bristles. Male genitalia rather short, swollen, distinctly wider than the abdomen, shining black in color; oviduct long and slender, about equal in length to segments 5, 6 and 7.

A male from Ithaca, New York, collected by Nathan Banks, August 10, 1889, and a male and female from Montgomery, Massachusetts, collected by Knab, August 24, 1896.

Asilus affinis Williston (Fig. 26).

Mystax of the male bright golden. Legs bright yellow with the exception of the posterior femora which are black. Length 15 to 16 mm.

Facial gibbosity prominent, mystax composed of abundant golden hair. Occiput with dark hairs above and pale hairs below. Thorax black, thinly clothed with dray dust, on the dorsum with numerous dark more or less bristly hairs; wings hyaline; legs largely yellow, each middle femur with a black marking above on the basal half, each hind femur and apex of each hind tibia on the outer side also black. Abdomen shining black, apex of each segment with a narrow gray border. Male forceps wide, excavated on the upper side at the apex.

The male type from which my description and drawing were taken are in the Francis Huntington Snow Collection at the University of Kansas. This specimen is from the state of Washington. Another male taken in the Santa Cruz Mountains of California by Coquillet is in the U. S. National Museum.

Asilus flavofemoratus n. n. (Fig. 27).

New name for Asilus flavipes Williston which is preoccupied by Asilus flavipes Wiedemann from Europe, Syst. Beschr. (1820) II, 325, 28.

Shining black, front and middle femora yellow with the exception of an elongate black marking above on each, hind femora black, all the tibiae yellow. Length 12–18 millimeters.

Face and front narrow, facial gibbosity prominent, but not reaching near to the antennae, mystax of the female composed of a few black hairs above and several white ones below, of the male almost entirely black, but sometimes partially golden and there may be other variations. Wings hyaline, very slightly gray at the apex and along the posterior margin. Each femur of the forward and middle legs with a black stripe above, hind femora black; all the tibiae yellow, each posterior black at the apex on the outer side; each metatarsus yellow with a black apex, other tarsal segments mostly black. Abdomen shining black, apex of each segment narrowly gray; upper forceps of the male entire above and of about the same width throughout.

Specimens at hand from Pa., Ohio, N. J., Va., Mass., N. Y., Ills., N. C., Md. and Canada. Common in the eastern part of the United States.

Asilus orphne Walker (Fig. 28).

A black species and in large part shining. Mystax golden, all the tibiae bright yellow and all the femora black. Wings hyaline. Length 12–19 millimeters.

Face narrow, covered with golden dust; facial gibbosity prominent and extending nearly to the antennae, mystax usually golden in color but varying to pale yellowish, composed of many slender bristly hairs; palpi and proboscis black, the former clothed with black hairs; occiput with black hairs above and pale ones below. Thorax black, thinly clothed with gray dust, hairs of the sides gray, of the dorsum mostly black; wings hyaline, very faintly gray at the extreme apex and along the narrow posterior border. Femora shining black, each front one usually yellow at the apex, each tibia and metatarsus yellow, black at apex, other tarsal segments largely black. Abdomen black, narrow margin of each segment above gray, clothed with gray hairs which are most abundant towards the base.

Commonly taken in the territory from Maine to Illinois and from Canada to North Carolina. Specimens also are at hand from Colorado and from Montana.

Walker's description of orphne fits the female of this species well. Dr. Johannsen agrees with me in identifying auceps. There is no doubt but that the species under consideration is distinctus and it is my opinion that this latter is the same as orphne, as is aeneobarbis which is a name sent by Loew in a letter to Osten Sacken without description. The name is sufficient to characterize the species however, when it is known that Loew's specimens were from the eastern United States.

Asilus coquillettii n. sp. (Fig. 29).

Black, all the femora black, all the tibiae in large part yellow. A prominent crest formed of black bristly hairs extends the whole length of the thoracic dorsum. In the region covered by this paper no other species has such a crest. Length 13–16 millimeters.

Facial gibbosity elongate and prominent and reaching nearly to the antennae. Mystax composed of an abundance of rather fine long hairs which are all black in the female and black on each side and otherwise white in the male. Front in both sexes with numerous long erect black hairs; antennae black, first two segments of each usually hairy; palpi black with black hairs; lower part of the occiput with some gray hairs otherwise with black hairs. Thorax thinly clothed with yellowish dust, a crest of long black bristly hairs on the middle of the dorsum reaches from the anterior part to the scutellum which also is furnished with numerous similar hairs. Wings hyaline; in the male each forward leg has the femur black, the tibia yellow with a narrow black apex, tarsus yellow with the exception of the fifth segment and its claws which are black; middle leg the same; hind leg black with the exception of a little more than basal half of the tibia which is yellow; in the female the legs are similar but the front and middle tarsi have the black including the apex of the first segment

and nearly all of the other segments. Abdomen shining black with narrow gray margin to each of the segments.

In some respects this species resembles affinis but the extreme hairiness of the head and thorax is characteristic, while there is a distinct difference in the color of the legs and a certain amount of distinction in the male genitalia.

Males and females collected by Coquillett in Santa Clara County, California. Types in the United States National Museum.

Asilus terminalis n. sp. (Fig. 30).

Gray dust on the thorax more dense than most species of this section of the genus, mystax in both sexes black around the outside, middle part pale yellowish, upper forceps of the male genitalia not excavated on the dorsal side at the apex. Length 14–17 millimeters.

Facial gibbosity prominent, long but not reaching the antennae, mystax in both sexes black above and below and with a row of black bristles on either side, thus the pale yellowish central hairs are entirely surrounded with black; palpi black with black hairs; antennae black, first two segments with rather short black hairs; beard white, vestiture of the upper part of the occiput black. Thorax with a covering of gray dust which largely obscures the black ground color, dorsum in front with short and posterior part with longer black hairs; scutellum with a number of long black bristly hairs on its margin and with numerous shorter black hairs on its disk; wings hyaline; front leg in both sexes with tibia and metatarsus, except the apex of each, and bases of the other tarsal segments reddish yellow, other parts black but in some specimens the apex of the femur may be narrowly yellow; middle leg the same, except there is slightly more reddish yellow at the apex of each tibia and metatarsus, and the femora are entirely black in all cases; hind leg black except a little more than the basal half of the tibia which is reddish yellow. Abdomen black with a narrow gray posterior margin to each segment and in the female especially each segment is partially gray on either side. Upper forceps of the male genitalia not very wide, about the same width throughout, rounded at the distal end but not excavated at the apex of the dorsal side as in all other western species of the same section of its genus.

Although this species is not striking in appearance its male genitalia mark it as entirely distinct from other known western species.

The male and female from San Antonia Canyon, near Ontario, California collected July 25, 1907.

Asilus brevicomus n. sp. (Fig. 31).

Black, middle portion of the mystax in the male white, otherwise black, in the female wholly black, hairs of the whole body decidedly shorter than in coquillettii. Length 15–17 millimeters.

Facial gibbosity long and prominent, in the male the mystax above and below and a row of bristles on either side black, middle portion white, in the female all black; front, and first two segments of the antennae furnished with short black hairs, occiput with black hairs above and white ones below. Thorax with short black bristly hairs

on the anterior half and longer ones on the posterior half. Wings hyaline, anal angle in the male with a small white area. Front leg with the apex of the femur, tibia and metatarsus except the apex of each, and the bases of the other tarsal segments yellow, otherwise black; middle leg similar but the femur is entirely black; hind leg black except three fourths of the tibia which is yellow. Abdomen shining black with a very narrow posterior margin to each segment gray. Upper forceps of the male appendages shining black, of nearly the same width throughout, superior side distinctly excavated at the apex.

The species is easily separated from affinis by the black forward and middle femora and from coquillettii by the very much shortened vestiture especially on the anterior half of the thorax.

Both sexes from Kalso, B. C., sent in by Harvey and Sherman, and a female from Los Angeles county, California, collected by Coquillett.

Asilus sadytes Walker.

This is the same as Asilus tibialis Macquart, which is preoccupied by A. tibialis Fabricius, Ent. Syst. (1793) IV, 383, 30; A. tibialis Fallen from Europe, Dipt. Suec. Asil. (1814) 9, 4; A. tibialis Wiedemann from Russia, Zool. Mag. (1817) I, 2, 29. There are at least two other species that have been described under A. tibialis, one from the Cape by Macquart himself and the other by Gimmerthal from Russia. Both of these latter have been named since the North American insect.

Black, abdomen with white border to each segment, femora black, tibiae and metatarsi largely reddish. Male forceps large and distinctly longer than abdominal segments six, seven and eight. Length 13–17 millimeters.

Face and front clothed with white dust, facial gibbosity prominent, mystax with numerous black hairs above and few white or pale yellowish ones below, although the distribution of black and light hairs varies through a series of specimens; antennae black, first two segments longer than the third which is about equal in length to its arista. Proboscis and palpi black, the latter with black hair. Beard white, occipito-orbital bristles black, remainder of the vestiture of the occiput white. Thorax rather thinly clothed with gray dust which has a yellowish tinge above, mid-dorsal stripe black; wing hyaline, apex and posterior margin slightly clouded; coxae colored like the thorax, femora black, tibiae largely reddish but usually with black markings on the outside, variable in a series of specimens; each metatarsus reddish with brown apex, other tarsal segments black or brown, each reddish at the base. Abdomen black with white posterior border to each segment. Male forceps large and longer than abdominal segments six, seven and eight.

Specimens are at hand from Ohio, Ind., N. Car., Mass., N. Y. and Pa. The species is common in sections of Ohio where I have collected in August.

Asilus notatus Wiedemann.

Black species. Legs black except the extreme base of each tibiae. Length 14–18 millimeters.

Face and front clothed with gray dust, facial gibbosity prominent, mystax with a few black hairs above and numerous pale yellow or white hairs beneath; beard white; occipito-orbital bristles mostly black, other bristles and hairs of the occiput white; proboscis and palpi black, the latter with black hair. Thorax mostly clothed with gray dust although the thorax has a yellowish cast; mid-dorsal stripe black, split anteriorly; wings hyaline, slightly clouded at the apex and along the posterior border; the legs are black except the narrow base of each tibia which is reddish; there is some variation in the legs, the reddish of the tibiae may be more extensive than indicated and the metatarsi may be reddish either wholly or in part. It is quite characteristic for this species to have areas of close lying golden pile, especially on the lower sides of the tibiae and metatarsi. Abdomen black, each segment narrowly white posteriorly. Upper forceps of the male genitalia small and short as compared with those of sadytes.

N. Y., N. J., D. C., Mass., Ct., Ills., Canada, Ind., Mo., Kan., Pa., Me. and Ohio.

Asilus callidus Williston.

Black, each abodminal segment with an apical white band, preapical band of each femur, each tibia and each metatarsus largely brown. Length 15–18 millimeters.

Facial callosity prominent, mystax black above and pale yellow or white below. Face and front clothed with gray dust, beard white; palpi and proboscis black, the former with black hair. Occipito-orbital bristles variable but always partially black and in some cases almost wholly black, other hairs and bristles of the occiput pale yellow. Thorax clothed with gray dust, mid-dorsal stripe black, narrowly divided anteriorly. Coxae colored like the thorax; femora black each with a preapical brown band; tibiae brown, each darker on part of the anterior side and at the apex; tarsal segments largely black, each brown basally or in case of the metatarsus brown except at the apex. Wing hyaline, clouded at the apex and along the posterior border, veins dark colored. Abdomen black, each segment with a white posterior border; male forceps in large part clothed with pale yellow hairs, rather suddenly curved at the tip, shorter than abdominal segments six, seven and eight.

Specimens from British Columbia and Washington.

Asilus novae-scotiae Macquart.

Dark brown body with plain black femora and yellow tibiae. Length 14–18 millimeters.

Face and front of ordinary width and clothed with yellow dust, facial gibbosity rather prominent, mystax composed of black hairs above and yellowish hairs below, but in some specimens the entire mystax is composed of light colored hairs; antennae black, third segment rather narrow and of the same length as its arista; occipito-orbi-

tal bristles mostly black above and yellowish at the sides, beard white. Thorax furnished with yellow dust, mid-dorsal stripe dark, narrowly divided anteriorly. Legs to the tips of the femora pure black, tibia yellow with black tips, metatarsi mostly yellow, other tarsal segments black, each with a narrow yellow base. Abdomen brown with narrow, light colored posterior margin to each segment. Male forceps about as long as abdominal segments six, seven and eight, oviduct shining black, first segment equal in length to abdominal segments six and seven, apical segment slender and style like.

The species is distributed, at least, from North Carolina to Canada and most specimens have been taken near the Atlantic coast, although there are records for Ohio.

Asilus antimachus Walker.

A light brown species with clear white mystax and with the legs almost wholly reddish. Length 16–20 millimeters.

Face and front clothed with gray dust. Facial gibbosity rather prominent, mystax and beard white; in some specimens there may be a very few black hairs just above the oral opening and once in a great while a specimen may be found that has a few short black hairs in the extreme upper part of the mystax; palpi and proboscis black, the former with black hair; some of the occipito-orbital bristles may be black but most of the hairs over the whole occiput are white; antennae black; first two segments together plainly longer than the third which is somewhat shorter than its arista. Thorax clothed with gray dust on the sides, and with yellowish dust above, mid-dorsal stripe and some spots on either side dark brown. Wings hyaline with slight coloring at apex and along the posterior border. Coxae colored like the sides of the thorax, femora largely red in most specimens, but varying from one having a small elongate black spot on the anterior side to one largely black with a wide preapical band; tibiae yellow, each with the apex narrowly black or brown, metatarsi yellow, each with a black tip; other tarsal segments black, some at least with yellow bases. Abdomen dull grayish brown, posterior margin of each segment lighter but the contrast between the segment and its margin not so pronounced as in novae-scotiae.

Common in various sections of Ohio in late summer. Specimens also from Indiana, Kansas, Virginia and Missouri. In the locality of Akron, Ohio, the species is abundant on weeds and in the pastures during the greater part of August.

Asilus maneei n. sp.

A small black species with black legs, gray stripes and markings on the thorax and gray posterior borders to the abdominal segments. Length 10–12 millimeters.

Facial gibbosity rather prominent, mystax composed of a mixture of gray and black hairs, face and front black but sparsely clothed with gray dust, beard white, occipito-orbital bristles black, proboscis and palpi black, the latter with black hair. Thorax black, largely covered with gray dust, the mid-dorsal stripe black but distinctly divided

by a white interval; legs black with not more than a suggestion of reddish at the bases of the tibiae, coxae with white hair, femora with some white hair and black bristles, other parts of the legs with short black hairs and prominent black bristles; wings hyaline, faintly gray at the apex and along the posterior border. Abdomen black with rather long gray hairs especially toward the base, and with the posterior border of each segment gray. The male appendages shining black, rather slender, elevated on distal half and about as long as abdominal segments six, seven and eight together. Oviduct shining black, distinctly compressed laterally, end lamella free and style like.

This species must have somewhat the appearance of Asilus anonymus Williston, from Mexico, but there are only two bristles on the margin of the scutellum, the third antennal segment is of about the same length as its arista, and there are other differences

A male and female taken in couple at Southern Pines, North Carolina, May 15, 1908, by A. H. Manee for whom the species is named.

Asilus delusus Tucker.

Gray brown. Preapical band and the posterior side of each femur red. Under side of each front femur with numerous rather long white hairs. Length 16–18 millimeters.

Mystax with numerous white hairs below and a few black ones above. Occipito-orbital bristles mostly black above, white on either side; thorax gray brown, mid-dorsal black stripe well defined, bristles on the posterior part prominent and black. Wing hyaline, clouded at the apex and along the posterior border. Front femur with the anterior side black, preapical band and the posterior side red; tibiae and tarsi mostly red, each tibia with a stripe on the anterior side and the apex dark, apex of each tarsal segment brown; middle leg the same; hind leg similar but the dark coloring of the tibiae more suffused. Abdomen gray brown, narrow posterior margin of each segment plainly gray.

Specimens from Kansas and Montana, those from Kansas being the types.

This was described as a variety of annulipes Macquart by Tucker whose identification of annulipes conforms to specimens called snowii in this paper, as I have determined by a study of the specimens used by Tucker. I agree that delusus is related to snowii but has a distinct general color over the entire body, the posterior side of each femur red and the third antennal segment shorter than in that species with the arista two thirds as long as the segment which bears it.

Asilus johnsoni n. sp. (Figs. 32 and 33).

Body bright yellowish, femora black outwardly, otherwise legs largely red, wing reddish, hyaline along many of the veins. Mid-dorsal stripe of the thorax prominent, brown and reaching the scutellum in nearly its entire width. Male genitalia uniformly red. Length 17–21 millimeters.

Facial gibbosity not especially prominent, mystax composed of a number of rather long pale yellow bristles below and a few shorter

black ones above; antennae black, third segment about as long as the first two together, arista more than half as long as its segment; occipito-orbital bristles coarse, black, beard colored like the mystax. Thorax with a distinct brown mid-dorsal stripe, bristles of the posterior part of the thorax black and rather prominent; tip of the scutellum with two black bristles. Front leg with the anterior side of the femur black, preapical band and the posterior side red; tibia red, marking on the anterior side and the narrow apex dark; tarsal segments sometimes wholly red but often each is dark at the apex; middle and posterior legs like the anterior ones. Wing reddish, margins of the veins in large part hyaline. Abdominal segments without distinct lighter posterior margins; male genitalia shining reddish, upper forceps rather small, narrow and straight from side view.

Males and females taken at Folson, Delaware County, Pennsylvania, July 7, 1893, by Charles W. Johnson for whom the species is named.

Asilus snowii n. n.

New name for Asilus annulatus Williston, which is preoccupied by A. annulatus Fabricius from East Indies, Syst. Ent. 1775, 794, 12; A. annulatus Macquart from France, Dipt. du Nord 1826, 36, 16.

A rather large dark brown species. Each femur with the exception of the preapical band, black; tibiae more or less distinctly annulate with black; under side of each front femur provided with numerous rather long hairs. Length 15–20 millimeters.

Mystax with black bristles above and white or pale yellowish ones below; antennae black, third segment long and rather slender, arista usually not over half the length of its segment. The row of occipito-orbital bristles mostly black, although in some specimens part of them are yellow. Thorax clothed with yellowish dust and with the usual markings and bristles above; wing in large part clouded with reddish, especially at the apex and along the posterior border, there is a tendency for many of the veins to be margined with hyaline, even in the clouded area. Each femur with a preapical reddish band, front and middle tibiae each with an annulus near the middle and the apex black, each metatarsus in large part yellow, black at the apex, other tarsal segments mostly black, usually narrowly yellowish at base; hind tibiae in large part infuscated, but a narrow basal space is always yellowish and there appears to be more or less variation in the extent of the black in a series of specimens. Abdomen clothed with dust so as to give it a dark brown color, posterior margins of the segments only slightly lighter.

Specimens are at hand from Canada, N. H., Mo., Penn., N. Y., Mass., Ills., Kansas and Ohio.

The type of annulatus is in Philadelphia and Mr. E. T. Cresson, Jr., through the kindness of Dr. Skinner, has compared specimens for me.

Asilus prairiensis Tucker.

A light brown species, preapical band and the posterior side of each femur brown. Front femur with close lying hair and several distinct bristles in a longitudinal row on the under side. Length 14–20 millimeters.

Mystax yellow with the exception of a very few short black hairs above, occipito-orbital bristles yellow, as are most all of the bristles of the whole body; third segment of the antenna long, nearly twice the length of its arista. Anterior femur with a red preapical band and posterior surface, otherwise black; tibia dark at the middle, especially on the anterior side and at the apex; metatarsus nearly entirely red, other tarsal segments mostly black; middle leg like the front one; hind leg the same except the dark color of the tibia is more suffused. Wing with the apex and the posterior margin faintly clouded, otherwise hyaline. In some specimens the hyaline tends to follow the margins of the veins into the clouded area. Abdomen yellowish brown, the gray posterior margins of the segments not very plainly marked.

Specimens are at hand from Kansas, Colorado, New Mexico and Texas.

This species in the southern states appears to occupy about the same position as paropus at the North. Macquart's description of annulipes from Carolina does not apply well to any of the robber-flies known to me from the northern states, especially is this true of the words "Cuisses fauves, brunatres en dehors," but does apply to the present species. These is an older Asilus annulipes by Brullé from Europe, so the name is not tenable for the American insect. With a large series of specimens before me showing quite a range in size and to some extent in coloration, the conclusion is reached that Tolmerus prairiensis Tucker is the same and being the name next available becomes the name of the species.

Asilus paropus Walker.

A medium sized species, femora entirely black with the exception of a reddish preapical ring; Wing reddish although hyaline along the veins of the disk and the base. Front femur with distinct bristles below. Length 13–17 millimeters.

Facial gibbosity prominent, mystax composed of numerous bristly hairs which are mostly pale but there are a very few black ones above. Antennae black, or at most only narrowly yellow at the apex of the second and the base of the third segments; occipito-orbital bristles in large part yellow but variable; in a pair taken in couple, these bristles are black in the female and yellow in the other sex. Thorax thinly clothed with yellowish dust and with the usual markings above, short black hairs anteriorly and long black bristles posteriorly. Wings distinctly reddish, most of the veins of the disk and toward the base plainly margined with hyaline. Front leg with the femur, except a preapical band, middle and apex of the tibia, narrow apex of the metatarsus and all except the extreme bases of the other tarsal segments black or infuscated, otherwise yellowish; middle leg like the

front one; hind leg similar but the tibia except a narrow base may be wholly infuscated. Specimens are before me in which all the tarsi are black and the light color of the tibiae is much encroached upon by the same. Front femur with close lying hairs and a row of distinct bristles on the under side. Abdomen thinly clothed with yellowish dust, posterior margin to each segment rather obscurely gray.

Specimens are at hand from N. H., Mass., Colo., N. M., Wyo., Toronto, Can., Ct., N. Y., Ills., Ind. and Ohio.

The species is somewhat variable in size and appearance, but I take it to be fully distinct. Walker's description fits quite well here and prospectus is likely a synonym.

Asilus rubicundus n. sp. (Figs. 20 and 21).

Uniformly reddish, mystax pale yellowish, bristles and hairs on all parts of the body light colored. Length 12 millimeters.

Face and front rather wide and clothed with yellow dust, facial gibbosity not very prominent, mystax pale yellowish, beard white, antennae dark, second segment lighter than the others, third segment about the length of the other two, arista near the length of its segment. Occipito-orbital bristles yellow. Thorax yellowish red with a wide darker mid-dorsal stripe; legs red, outer side of each femur and apex of each tibia slightly darkened; wings small, hyaline, only a slight clouding at the apex and along part of the posterior border. Abdomen yellow, two or three light bristles on each side before each of the incisures; genitalia red, upper forceps of the male quite wide at the tip and evenly rounded.

Specimens of this small and distinct species have been taken at Onaga, Kansas, by Crevecoeur in June and July, and in southern Illinois, near Carbondale, also in the same months. The latter specimens are in the Illinois state collection of insects at Urbana.

Asilus mesae Tucker.

Very small species, clothed with pale yellow dust, bristles of the body and legs, all light colored. Genitalia in both sexes red. Antenna with a very short arista which is hardly differentiated from its segment. Length 8–12 millimeters.

Facial gibbosity small, mystax composed of pale bristles, antenna black, the third segment is characteristic for instead of having the usual differentiated arista this segment gradually tapers to the apex, occipito-orbital bristles pale yellow. Ground color of the thorax hidden by a coating of yellow dust, wings small and hyaline, slightly clouded at the tip. Femora usually black but variable; tibiae reddish each darker at the apex, tarsi mostly dark, although each metatarsus usually is reddish on the basal part. Posterior margin of each abdominal segment narrowly light colored. Genitalia red.

Usually the small size of this species will lead to its recognition, but it may be confused with rubicundus, from which its antennae will readily distinguish it.

Specimens are at hand from Colorado, Wyoming and Kansas. The types are in the Francis Huntington Snow Collection.

Asilus erythocnemius n. sp.

Dark brown species, each femur except a preapical band black, other parts of the legs largely red. Third antennal segment rather wide, arista almost as long as its segment, nearly all the bristles of the body and legs black. Length 11–14 millimeters.

Facial gibbosity reaching about half way to the antennae, mystax composed mostly of pale yellow bristles although there are a few short black ones above, occipito-orbital bristles black, beard white. Thorax clothed with yellow dust, but with a distinct black mid-dorsal stripe. Wing hyaline, slightly clouded at the apex and along the posterior border; femur of each leg black with the exception of a preapical band which is red; each tibia red, usually with a dark marking near the middle of the anterior side, apex also dark; metatarsi red, other segments mostly black. There is a tendency in some specimens for the hind tibia to be darkened more or less leaving only a narrow band at the base yellow, especially is this coloring apt to show on the anterior side. Front femur with a row of rather weak white bristles on the lower side. Abdomen colored like the thorax, two or three small bristles on either side before the incisures; from side view the upper forceps of the male genitalia widest at about two thirds the length, lower side nearly straight.

Specimens from Mass., N. Y., Ct., N. J., Kan., Mont., Colo., Md., Wyo. and Ohio.

Asilus astutus Williston (Fig. 35).

Yellowish brown species, form rather robust, femora black anteriorly, preapical band and posterior side red. Thorax and legs with black bristles. Antennal arista about one third as long as the segment which bears it. Length 15 millimeters.

Facial gibbosity most prominent just above the oral opening, gently sloping to the level of the face about half way to the antennae. Mystax mostly pale yellow but with several black bristles above, beard pale yellow; antenna black, third segment distinctly longer than the first two together, arista about one third as long as the third segment. Occipito-orbital bristles straw yellow. Thorax clothed with yellow dust, mid-dorsal stripe dark brown and distinctly split on the anterior part. Wing in large part clouded, base and disk largely hyaline. Each femur black anteriorly with a preapical red band, red posteriorly; front femur with a few black bristles beneath; each tibia dark anteriorly with a narrow red base, posterior side red; tarsal segments red, each more or less darkened apically. Abdomen clothed with yellowish brown dust, posterior margins of the segments not distinctly lighter; no bristles before the incisures. In the type male specimen before me only seven abdominal segments are visible. Genitalia rather small and red.

The types are in the Francis Huntington Snow Collection and are labelled as coming from California. There are no other records of the occurrence of the species known to me.

If Loew's names were used this species would come in Antiphrisson without any question. The form and color taken in connection with the male genitalia which are figured in the plate, and the absence of bristles before the margins of the abdominal segments make the species rather easy of determination.

Asilus californicus n. sp. (Fig. 36).

Dark colored species, wings clear hyaline, legs mostly yellow, preapical bristles of the abdominal segments light colored, upper forceps of the male genitalia split at the apex. Length 21 millimeters.

Face and front of usual width, facial gibbosity prominent, mystax with a row of rather fine black bristles around the outside, remainder composed of coarser white bristles; palpi black with light hair; antenna black, third segment about as long as the first two together, arista not quite as long as its segment; bristles and hairs of the occiput light with the exception of a few rather strong bristles just back of the upper part of each eye. Thorax dark gray, mid-dorsal stripe black but divided by a distinct gray interval. Wings clear hyaline and wider than usual; front femur black on the anterior side for the basal half of its length, otherwise yellow; tibia yellow, narrowly black at the apex; metatarsus yellow, other tarsal segments black; middle leg like the anterior with the addition or black at the tip of the anterior side of the femur; posterior leg the same as the middle one except that the black of the femur takes the form of a stripe not reaching either end. Abdomen dark gray, posterior margin of each segment only slightly lighter and preceded by a prominent row of yellow bristles. Male genitalia shining black with numerous long black bristly hairs especially beneath; upper forceps rather long, of nearly the same width throughout, apex split with the lower division the longer and curved inward.

A male of this distinct species from Cisco, California, altitude 5,000 feet, taken in June, 1901, and received from Charles W. Johnson.

Asilus sericeus Say.

A large brown species with brown wings and pale brown legs. Length 20–28 millimeters.

Facial gibbosity with the most prominent point on a level with the lower edge of the eye, mystax composed entirely of yellow bristles, palpi black with black hairs, first and second segments of the antennae yellow, third segment black and decidedly longer than the first two together, arista about one fourth as long as its segment; bristles and hairs of the occiput all yellow. Thorax clothed with bright yellow dust, mid-dorsal stripe dark brown, reaching the scutellum in its full width; wings brown, veins margined with paler; legs pale brown, each femur usually with a dark marking on the anterior side. Abdomen colored like the thorax, no bristles before the incisures.

Generally distributed over the eastern part of North America from Canada to Texas and at least as far west as Kansas.

Asilus midas Brauer.

Entire body and legs velvety black, pulvilli on all the feet pale brown, hairs and bristles everywhere black except in the male there is a tuft of white hairs on each cheek below the eye. Wings rich brownish yellow all over. The species cannot be confused with any of the others of its subfamily. Brauer called attention to its close resemblance to a species of Midas from the same locality in Mexico where the type was taken.

Specimens from New Mexico and from Oak Creek Canyon, Arizona, taken in August by Dr. F. H. Snow are in the museum of the University of Kansas at Lawrence.

Asilus nitidifacies Hine (Figs. 37 and 38).

Black, wings slightly fumose, face just beneath the antennæ shining black; female with conical oviduct. Length, 12 to 15 mm.

Facial gibbosity rather prominent, and clothed with black bristles above and white bristles below; face just beneath the antennae shining black, otherwise clothed with gray dust, which is most pronounced along the entire margins of the eyes; third segment of the antenna rather narrow and a little longer than the first two together, arista only about half as long as its segment, beard white; occipito-orbital bristles all black. Ground color of the thorax black, but thinly covered with gray dust, four to six black bristles on the margin of the scutellum; wings slightly fumose, almost hyaline on basal parts. Femora all black, with fine white hair and black bristles; tibiae and tarsi more or less dark red, approaching black in parts. Hind tibiae each with three or four black bristles on the front side near the middle. Abdomen black above, with gray hind borders to the segments, but not preceded by bristles that differ from those on the other parts of the abdomen.

A male specimen collected in the Hope Mountains of British Columbia by R. S. Sherman, July 16, 1906, and a female collected on Vancouver Island, July 2, 1903, by R. V. Harvey. Also specimens in the United States National Museum from Mt. Hood, Oregon, taken by H. K. Morrison.

Asilus cacopilogus n. sp.

Gray, wings rather narrow and hyaline. Upper forceps of the male genitalia not protruding beyond the other part, which is terminated by a distinct pencil of long white hairs. Length 15–18 millimeters.

Facial gibbosity not prominent, mystax composed of numerous white bristles, antennae, palpi and broboscis black, palpi and first two segments of each antenna with black hair, otherwise bristles and hairs of the whole head white, third antennal segment distinctly shorter than the first two together, rather wide, arista fully as long as its segment, front and face clothed with gray dust. Thorax gray, above with two brown stripes on the anterior part; legs largely black, base and apex of each femur and basal half or more of each tibia reddish, the posterior side of each may be partly or entirely reddish, and there

are other variations in the extent of the black and reddish of the legs in the specimens at hand; claws and pulvilli long and quite slender. Wings hyaline, posterior branch of the third vein bent slightly forward at the middle of the length beyond the furcation and then backward just before the margin of the wing. Abdomen dark, thinly clothed with gray dust and numerous gray hairs which are longest at the sides. Ovipositor black with a circlet of spines at the tip; male genitalia rather short, superior part not protruding beyond the other part which is tipped with a pencil of long white hairs.

Specimens from Rosser, Texas, taken by F. C. Pratt; Clark County, Kansas, by F. H. Snow; Anglesia, New Jersey, by H. S. Harbeck, Havana, Illinois, and from Admore, Oklahoma; Fromont, Nebraska, and from other places in Texas besides the one mentioned. It appears to be more eastern in distribution than leucopogon.

This name was carried by some specimens in the Francis Huntington Snow Collection but I cannot find that any description has ever been published.

Asilus leucopogon Williston.

Light gray, wings hyaline, scutellum sparsely clothed all over with rather long white bristles, male genitalia with the superior part protruding at least half its length beyond the inferior part which is without the pencil of hairs present in cacopilogus. Length 15–18 millimeters.

Face and front broad, clothed with nearly white dust, facial gibbosity most prominent just above the oral opening, gradually sloping to the level of the face slightly below the insertion of the antennae, mystax composed entirely of white bristles. Antenna black, third segment shorter than the first two together, arista about as long as its segment, palpi and proboscis black, the former with black hair; beard white, occipito-orbital bristles white or very pale yellowish. Thorax gray, mid-dorsal brown stripe not conspicuous, wings rather narrow and hyaline; legs in large part red, each femur on the anterior side with a black marking which varies in extent in different specimens; each tibia infuscated toward the tip. Abdomen darkened somewhat and often with distinct gray posterior margin to each segment. Oviduct usually shining black, but reddish in part in some specimens, male genitalia usually red, superior part extending beyond the inferior part for about half its length.

Professor Aldrich has kindly sent me a pair of this species from the material which Williston had when he wrote the original description.

Specimens are at hand from Pierre, South Dakota; from Morton County, Kansas, and Bill Williams Fork, Arizona, collected by F. H. Snow. A number of specimens collected by myself near Tombstone, Arizona, August 5, 1907, are larger than the others and distinctly more reddish in color but present no structural differences.

Asilus arizonensis Williston (Figs. 39, 40 and 41).

Ground color of the body dull black, posterior margin of each abdominal segment plainly yellowish gray, wings uniformly fumose, legs reddish. Length 16 to 19 millimeters.

Gibbosity of the face small, clothed with white bristles, sometimes the two uppermost bristles are black; face and front clothed with gray dust. Antennae black, or in some cases partially reddish, first segment of each nearly twice as long as the second, third segment, without the arista, a little shorter than the first two together, arista about equal in length to the third segment; bristles of the rear of the head light colored, although one or two on each side are often black. Thorax clothed with yellowish gray dust, notum with the usual darker areas; wings uniformly light smoky brown; legs reddish in general color, coxae clothed with gray dust and hairs; outer side of each femur, apex of each tibia and all of each tarsus beyond the apical part of each metatarsus infuscated. Abdomen dull black above, posterior border of each segment with a yellowish gray band, sides and venter gray.

The type of this species is in the Francis Huntington Snow Collection. It is a female and is labelled as coming from Arizona. Besides I have studied a male and two females from southern Arizona and fifteen males and females taken in the Huachuca Mountains of Arizona by myself July 28, 1907. Most of the latter specimens were taken from stones lying at the edge of a small brook where they had stationed themselves to watch for insects they desired for food.

This is the largest North American species of its group so far known. The wing in the type is just a shade lighter than in the other specimens. It is possible that this is due to fading for the specimen appears as if it is fully developed. The species is very easy to identify on account of its large size and almost fumose wings.

In a former paper published in the Ohio Naturalist, I identified the next species as arizonensis, but after studying the type it is evident that that conclusion was wrong. I did not have specimens of the present species when I wrote the paper referred to.

Asilus limpidipennis n. sp.

Gray species with hyaline wings and red legs. Body of the male quite slender, legs distinctly more slender than in arizonensis. Length 17 millimeters.

Gibbosity of the face very small, with a few white bristles; front and face white; bristles and hairs of the head all white; first segment of each antenna black, second more or less yellowish and shorter than the first, third black, exclusive of the arista about as long as the other two together, arista slender and slightly shorter than the third segment. Thorax covered with gray dust with a mid-dorsal dark stripe, narrowly divided before, and two spots on each side, one before and the other behind the transverse suture. These brown markings are not so prominent as in some of the other species of the genus. Wings hyaline, legs largely reddish, coxae colored like the thorax, femora

with more or less black on the outer side, especially on the apical half; tibiae and metatarsi black at the apexes, other tarsal segments mostly black. Abdomen dull black, before the incisures with narrow white bands, in the front margin of which there are on either side in each two or more bristles.

Male and female taken in south-western Colorado, July 14, 1899, by E. J. Oslar.

In a former paper published in the Ohio Naturalist I identified this species as arizonensis but after studying the type of that species have come to the conclusion that the preceding must bear that name.

Asilus fuscatus n. n.

New name for Philonicus obscurus Hine which is preoccupied by Asilus obscurus Meigen from Europe, Syst. Beschr. (1820) II, 315, 12.

General color dark with the wings pale fumose all over. The abdomen has different shades according to the angle from which it is viewed. Length 10 to 16 millimeters.

Gibbosity of the face small with a few bristles, part of which are black and the others white; face with gray dust, front with some small black bristles and occiput above with a row of black bristles; antennae black, first segment of each longer than the second, third, exclusive of the arista, about as long as the other two together; arista a little shorter than the third segment. Thorax clothed with brownish gray dust, with a mid-dorsal dark brown stripe narrowly divided before, and on either side two spots of the same color, one before the transverse suture and the other behind it. Wings uniformly darkened all over, but it would not be far wrong to say that they are hyaline. Legs black and reddish; coxae colored like the sides of the thorax, femora entirely black except that the posterior ones are often narrowly yellowish at the extreme base of each; tibiae reddish at the base and black at the apex of each; the extent of the two colors on the tibiae is somewhat variable, the tendency being for the black to be most extensive on the outside and the reddish on the inside; feet with the first two segments of each reddish on basal part, other segments usually entirely black. Abdomen opaque black, before the incisures with gray bands, in the front margin of each of which on either side are two or more distinct bristles.

A male from Kentucky, across the river from Cincinnati, collected by Charles Dury; two females from Washington, D. C.; males and females from Riverton, N. J., and Pendleton, N. C., procured from Mr. Charles W. Johnson; several specimens from New Jersey and Pennsylvania, collected by H. S. Harbeck; also specimens from New York, Massachusetts and Virginia.

Asilus rufipennis Hine.

General color gray, legs reddish, wings of a uniform reddish color all over. Length 15 millimeters.

Gibbosity of the face small, furnished with a few bristles which usually are all white, but in one or two of the species studied there is now and then a black bristle mixed with the others; face and front

with silvery dust; occipito-orbital bristles black; first segment of each antenna black, second large yellowish and shorter than the first, third black, not quite as long as the first two together, arista slender, about the length of the third segment; beard entirely white. Thorax clothed with gray dust but with a mid-dorsal brown stripe narrowly divided before and two spots of the same color on either side, one before and the other behind the transverse suture; coxae gray, usually an elongate blackish spot on the anterior side of each femur and extreme apexes of all the tibiae and the tarsal segments blackish, otherwise legs red. Wings uniformly reddish yellow all over, halteres pale yellow. Abdomen opaque black with a narrow gray band in front of each incisure and in the anterior margin of each of these bands there is on either side two or more bristles.

Specimens from Douglas County, Kansas, taken in May and June by E. S. Tucker. Also a specimen from Havana, Illinois, taken June 9, 1905.

Asilus truquii Bellardi (Figs. 42 and 43).

Grayish black, wings pale reddish, thorax with a distinct dark mid-dorsal stripe; legs slender, femora mostly black anteriorly. Angle at the middle of the superior side of each part of the male upper forceps produced inward and backward until it meets and crosses its fellow of the opposite side. Length 12 to 14 millimeters.

Facial gibbosity very small, mystax composed of a few bristles, some of the upper ones of which are black and the others white; antennae black, bristles and hairs of the occiput nearly all gray but there may be a couple of black bristles behind either eye. Thorax yellowish gray with a distinct, nearly black mid-dorsal stripe; wings pale reddish all over; legs slender, femora largely black anteriorly, reddish posteriorly; each tibia and metatarsus red, dark at the apex; other tarsal segments in large part black, narrow base of each red. Abdomen gray black with the posterior border to each segment narrowly gray. Oviduct black, short, conical with four spines at the tip above.

Specimens from Mexico taken in August. Bellardi, Osten Sacken and Williston have reported the species from various parts of the same country.

Asilus tuxpanganus Bellardi.

Rather small dark colored species, legs black except a red interval at the base of each tibia, wings with a slight smoky tinge. Length 11 to 15 millimeters.

Gibbosity of the face small with a few bristles which are black above and white below; face rather narrow and clothed with white dust; each antenna black, first two segments with black hairs, second segment shorter than the first, third slightly shorter than the first two together. Arista slender and a little shorter than the third segment, palpi and proboscis black, beard white. Thorax everywhere clothed with silvery dust, above with two black stripes near the middle of the

notum and two spots of the same color on either side, one before and the other behind the suture; wings with a slight smoky tinge but this is so faint that they well may be called hyaline and there is no apparent darkening at the apexes as in many species of the subfamily Asilinae. Coxae silvery, extreme base of each tibia reddish, otherwise legs black with black bristles; halteres pale throughout. Abdomen shining black above with narrow white bands in front of the incisures; in the anterior border of each white band there is on each side two or more medium sized bristles, more prominent in the male than in the female; venter of the abdomen silvery and with a few white hairs.

Taken at Gualan, Guatemala, January 13th, and at Mazatanango, Guatemala, February 3, 1905.

EXPLANATION OF THE PLATES.

FIG. 1. Side view of the male genitalia of Asilus gracilis.
FIG. 2. Side view of the female genitalia of A. gracilis.
FIG. 3. Side view of the male genitalia of A. lecythus.
FIG. 4. Side view of the female genitalia of A. lecythus.
FIG. 5. Side view of the male genitalia of A. tenebrosus.
FIG. 6. Side view of the male genitalia of A. avidus.
FIG. 7. Side view of the male genitalia of A. occidentalis.
FIG. 8. Side view of the male genitalia of A. auricomus.
FIG. 9. Dorsal view of the male genitalia of A. auricomus.
FIG. 10. Side view of the male genitalia of A. piceus.
FIG. 11. Dorsal view of the male genitalia of A. piceus.
FIG. 12. Side view of the male genitalia of A. montanus.
FIG. 13. Dorsal view of the male genitalia of A. montanus.
FIG. 14. Side view of the male genitalia of A. albicomus.
FIG. 15. Side view of the male genitalia of A. lepidus.
FIG. 16. Dorsal view of the male genitalia of A. lepidus.
FIG. 17. Side view of the male genitalia of A. willistoni.
FIG. 18. Dorsal view of the male genitalia of A. willistoni.
FIG. 19. Side view of the female genitalia of A. willistoni.
FIG. 20. Side view of the female genitalia of A. rubicundus.
FIG. 21. Side view of the male genitalia of A. rubicundus.
FIG. 22. Side view of the male genitalia of A. angustipennis.
FIG. 23. Dorsal view of the male genitalia of A. angustipennis.
FIG. 24. Side view of the male genitalia of A. latipennis.
FIG. 25. Dorsal view of the male genitalia of A. latipennis.
FIG. 26. Side view of the male genitalia of A. affinis.
FIG. 27. Side view of the male genitalia of A. flavofemoratus.
FIG. 28. Side view of the male genitalia of A. orphne.
FIG. 29. Side view of the male genitalia of A. coquillettii.
FIG. 30. Side view of the male genitalia of A. terminalis.
FIG. 31. Side view of the male genitalia of A. brevicomus.
FIG. 32. Side view of the male genitalia of A. johnsoni.
FIG. 33. Side view of the female genitalia of A. johnsoni.
FIG. 34. Side view of the male genitalia of A. erythocnemius.
FIG. 35. Side view of the male genitalia of A. astutus.
FIG. 36. Side view of the male genitalia of A. californicus.
FIG. 37. Side view of the male genitalia of A. nitidifacies.
FIG. 38. Dorsal view of the female genitalia of A. nitidifacies.
FIG. 39. Side view of the male genitalia of A. arizonensis.
FIG. 40. Dorsal view of the male genitalia of A. arizonensis.
FIG. 41. Side view of the female genitalia of A. arizonensis.
FIG. 42. Side view of the male genitalia of A. truquii.
FIG. 43. Dorsal view of the male genitalia of A. truquii.